Metals and Alloys

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PRODUCTION · FABRICATION · TREATMENT · APPLICATION

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Feature Articles

Special Metal-Working "Conversion" Section

With the issuance early this month of General Conservation Order M-126, no metal-industries engineer or manufacturer retains the slightest doubt concerning the absolute necessity for conversion to war production *now* if his conversion is not yet underway. Of timely help, therefore, should be the 16-page "Metallurgical Engineering Conversion to War Production" section starting on page 763 of this issue and containing 7 practical, instructive articles on planning the conversion, getting sub-contracts and solving operating problems after conversion is accomplished.

Open Hearth Developments

This issue, dedicated to the annual conference of the Open Hearth and Blast Furnace Committees of the A. I. M. E. contains—in addition to an "on-the-premises" report of the Conference by E. F. Cone (page 783)—a stimulating article on alloy conservation in the open hearth by W. J. Reagan (page 741) and the useful results of a new slag-control investigation by F. W. Scott & T. L. Joseph (page 745).

Powder Metallurgy of Tin

The manufacture and uses of tin powder and tin alloy powders—bronzes included—are topics that have seldom been discussed. H. C. Watkins (page 751) presents useful and interesting information on the making of tin-base powders and their applications for powder-metallurgy fabrication and otherwise.

Fabricating Copper Steels

The general hot-fabricating problems associated with copper-bearing steels and their practical solutions are further discussed in the second instalment of F. Eberle's article, the first part of which appeared in April.

Metallurgical Engineering Digests

Tearing of Steel Castings

Every defect in a steel casting today represents a potential drag on the victory line, and every possible source of trouble should be vigorously eliminated. Andrew (page 842) discusses tears in steel castings as related to sand-fineness. (It's not strictly a Digest, but be sure to read also the steel castings dope in the A. F. A. convention report on page 802 of this issue.)

Secondary Copper

An able analysis and report of wartime practice in the utilization of scrap copper is presented by Thum (page 850).

Machining Cast Iron and Steel

More knowledge on the relative machinability of specific types of steel and cast iron will speed up the machining of countless war products. Smith (page 858) adds to the growing fund of information.

Welding Splatter

Excessive and wasteful splatter in welding, an economic felony ordinarily, is an outright crime these days. Spraragen & Claussen (page 864) do a correlated abstract on the subject and come up with some practical suggestions.

Substitute Solders

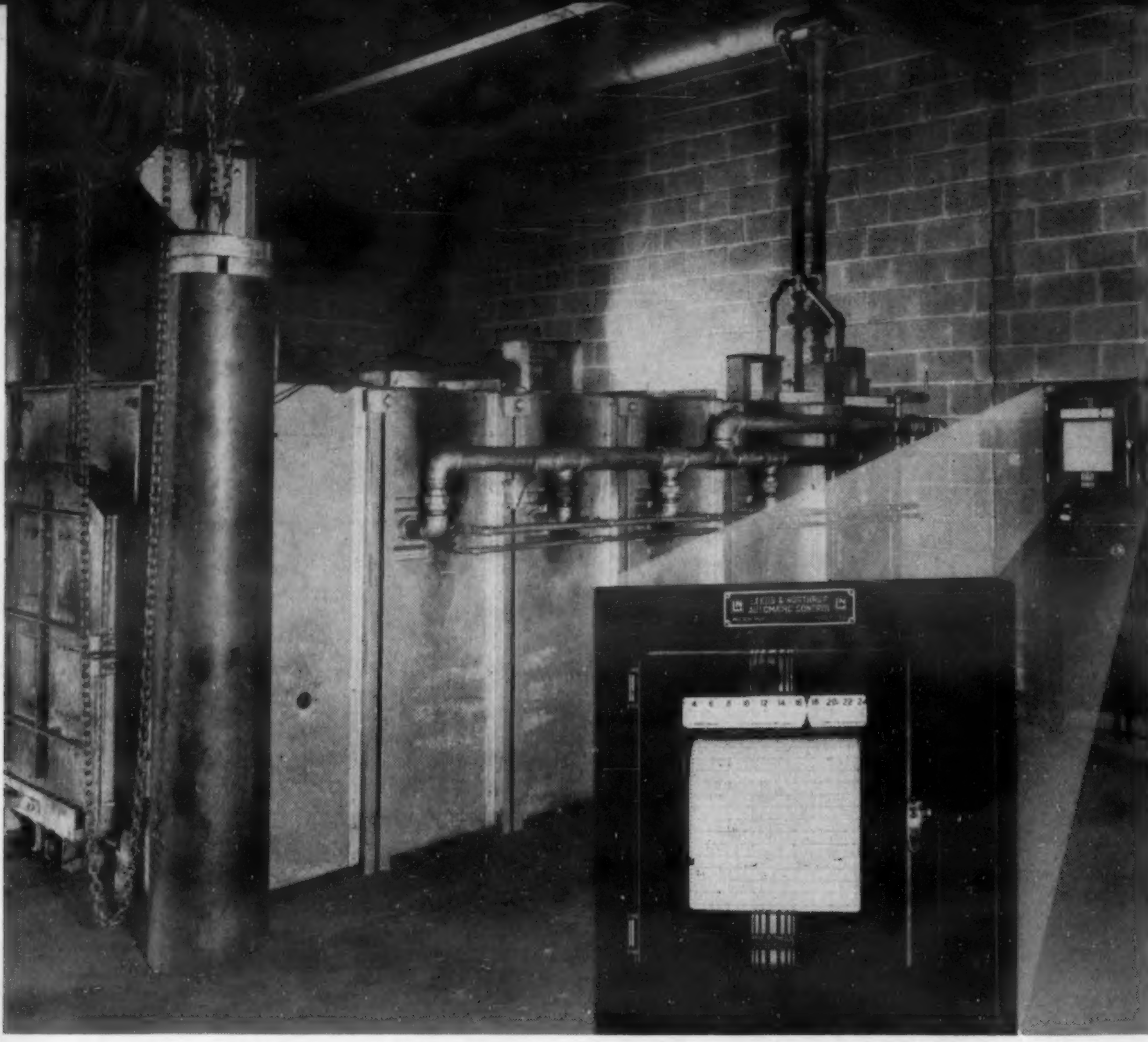
The lead-silver substitute solders *may* be the regular solders of tomorrow, but they definitely *are* becoming the regular soldiers of *today*, says Gillett (page 868) in a WPB report.

Plastics for the Engineer

Much more than the one-time answer to the gadget-maker's dream, plastics are today important engineering materials and are increasingly appraised for structural purposes. A comprehensive discussion of plastics in engineering is given by Caress (page 876).

Instrumentation in Heat Treating

Beck (page 898) describes some typical temperature control systems as applied to modern heat treating furnaces.



Because of the kind of work it's doing right now, no photograph may be taken of the furnace referred to below, but this picture shows a unit of comparable gas consumption.

100,000 Ft of Gas Per Month Saved for War Use by Micromax

When a new industrial furnace was being installed in a certain plant, the orders failed for some reason to include a control pyrometer. The furnace was badly needed, however, so it was fired up under manual control, while its Micromax Controller was being rushed to the job. The before-and-after results of Micromax Control were most interesting.

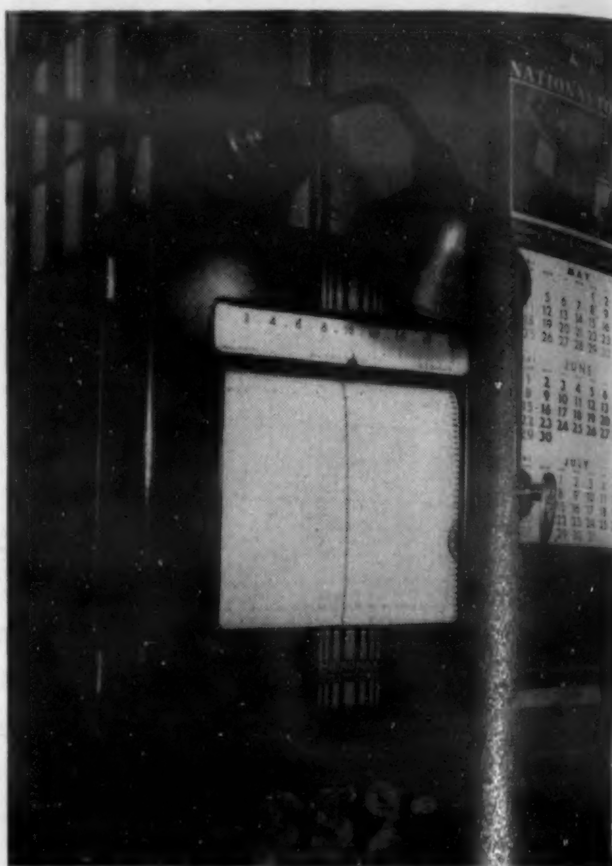
The first result, when Micromax was installed, was a cheer from the foreman, because he was tired of tending the furnace by hand. Next, management cheered, because the furnace's gas bill dropped $50 per month. And finally the gas company joined in, because the saving gave them 100,000 feet more fuel per month, urgently needed by other war plants. This 100,000 feet was ten per cent of the furnace's fuel.

The Micromax qualities which made possible maximum savings in this case are available to every user, and are often as valuable on old furnaces as on new ones. For Micromax Controllers can be quickly applied to any furnace. Thousands are doing fine jobs by simply opening a by-pass valve wide when temperature drops and closing it tight when temperature rises again. Other thousands use a control in which the valve moves *in proportion* whenever there's a temperature change. This is control at its best. It automatically does the right thing even when someone opens the furnace door; when the fuel pressure changes; when the furnace is loaded to capacity as well as when it's almost empty.

If you have a war-time job of temperature control, one of our engineers will be glad to talk it over with you, on request. Or perhaps you'd rather just have our Folder N-00A(1), which describes the Controller.

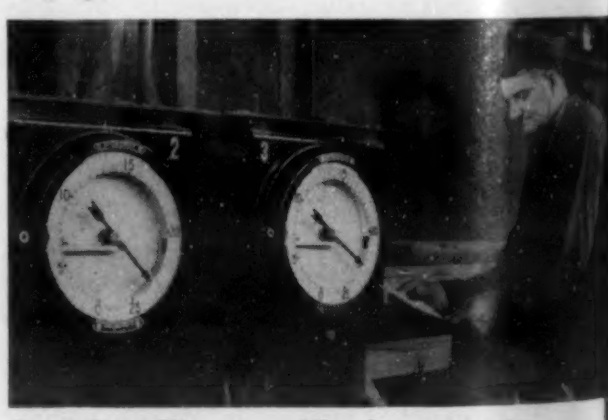
Correct Anneal of Guns Is Shown By Micromax In Big Ordnance Plant

Makers of big guns, periscope tubes, giant crankshafts and similar heavy forgings for the Army and Navy are generally required to prove, by pyrometer charts, that the annealing has been done as specified in orders. Many of these forgings makers rely on Micromax Pyrometers for this exacting duty; we show here some typical applications.



Strip-Chart Micromax Pyrometer Recording the anneal of a big gun barrel.

The strip-chart Micromax is one of a battery, located in a temperature-control room. The door is locked against all except inspectors, and the pyrometers thus give impartial reports of the annealing of "fighting" forgings.



Round-Chart Micromax guiding furnace operator.

The round-chart Micromax pyrometers are mounted right alongside the big annealing furnaces, to guide the operators in holding the temperatures reported by the strip-chart machines. Their big dials and bold arrows enable the men to see from a distance, without hovering continuously over them.

In addition to these two Micromax models shown, there are 3 others available in hundreds of ranges. One or another will handle any temperature problem of any industrial furnace. They are described in Catalog N-33A, sent on request.

Jrl Ad ENT-0600C(46)

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MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Ships, Airplanes and Guns

From time to time groups of business paper editors go to Washington and hear certain key men in the Government deliver intimate and off-the-record talks on subjects in various fields of industry. These meetings are splendidly organized and handled and afford editors not only a background of valuable information but also an opportunity for these officials to get across certain facts to the readers of the business and technical press.

We had the good fortune to attend one of these recent gatherings, the theme of which was — "More Ships, More Airplanes, More Guns." We heard such men as General Marshall, chief of staff, General H. H. Arnold, chief of the Army Air Corps, Admiral Emory S. Land, chairman of the Maritime Commission, General C. M. Wesson, chief of ordnance of the Army, Admiral W. H. P. Blandy, chief of ordnance of the Navy, and others. In all cases we were impressed with the need, in this titanic struggle, of ships, airplanes and guns in ever increasing numbers and speed. Also we felt deeply the urge for a "freezing of present relationships" for the duration by all concerned and the passing on of this message to management, labor, Congressmen, civilians and all others. We were reminded of an address we heard not long ago by a Britisher who recounted how all British interests at the time of Dunkerque forgot all controversies and hours of labor or wages, and worked together to save England.

In these few paragraphs we hope to pass on to all who read them — capitalist, labor leader, civilian and so on — the great necessity for unity and hard work, the abandonment of everything that will impede or tend to slow up the output of ships, airplanes and guns, or any war equipment. We came away from this meeting filled with the firm conviction that our war equipment is and will be in the hands of loyal and highly competent patriotic men. Let us give them the tools. —E.F.C.

Progress in Centrifugal Casting

Progress in the art of casting metals centrifugally is rapidly expanding to new products. Several announcements have recently appeared in the daily press that the Ford Motor Co. is producing centrifugally cast steel aircraft engine cylinder barrels. We have confirmation

(Continued on page 739)

(Continued from page 737)

of this from the company. It is also true that the Ford company is casting many other parts such as landing gear axles, solid projectiles, etc., by similar methods.

But these developments are not the first by Ford metallurgical engineers. In the last war Ford and others cast bushings centrifugally. About four or five years ago, Ford developed a centrifugal process and equipment for making steel gear blanks — described in METALS AND ALLOYS for October 1938. This has been expanded to large scale mass production.

Undoubtedly there are marked advantages in the centrifugal process, though it is largely limited to cylindrical shapes. One distinct advantage is a decided conservation of metal—very important in the war effort when every ton, or even pound, of metal saved means so much gained. For example, in the case of the cylinder barrels, there is an initial saving of 35 lbs. or 45 per cent, in the steel used—the steel block for the forged cylinder barrel weighs 72 lbs. while the centrifugally cast cylinder barrel weighs only 37 lbs. And there are marked savings in machining and in cost of equipment.

As a process the centrifugal method is of course not new. It has been successfully applied to both ferrous and non-ferrous metals and alloys for many years. Sandusky Foundry & Machine Co. makes bronzes and Watertown Arsenal casts steel guns centrifugally. Even the dentist makes centrifugal castings. In the ferrous field probably the oldest is the production of cast iron pipe by the de Lavaud process, first exploited here over 20 years ago and described for the first time in 1916. Now a large proportion of the country's output of cast iron pipe is made by two centrifugal processes.

The more recent developments in steel have been hastened by the cogent urge to save metal and to speed output without sacrifice of quality. One result is probably the earlier fruition of new developments and another proof that "necessity is the mother of invention."

—E.F.C.

Expansion in Magnesium

Magnesium has become a major factor in the War Program. In 1940, the output of this metal was only a little over 6,250 net tons. In 1941, this had been increased to about 16,500 tons. According to a recent statement of W. L. Batt of the WPB, this is to be stepped up this year to approximately 362,500 tons—an expansion over 1940 of nearly 60-fold. The realization of this program will outstrip the expansion in a short time of any metal in history.

Supplementing the familiar Dow and other processes for producing magnesium, the ferrosilicon reduction process has come into the picture. In Canada and in this country several companies are building or are to build, plants which will use this method in some form. Briefly, high grade ferrosilicon is mixed with dolomite, heated in a vacuum, whereby the magnesium is distilled and sublimed. The practically pure metal can be removed from retorts or other apparatus in solid form. It is estimated that about one-fifth of the total magnesium to be produced will be made by this method.

Dolomites exist in abundance in the United States and Canada and it is perhaps surprising that this comparatively simple method has not been introduced earlier. This is probably explained by the fact that, until the war increased the demand, the electrolytic treatment of magnesium chloride sufficed. —E.F.C.

Pouring an open-hearth heat—from the original drawing by Don Burns of Buffalo, N. Y. (Courtesy: The Morton Galleries, New York)

Conservation of Alloys in the Open-Hearth

by W. J. REAGAN

Superintendent of the Open-Hearth Dept., Edgewater Steel Co., Pittsburgh

Steelmaking under today's wartime conditions involves problems absolutely foreign to normal operations. The alloy stringency has not only eliminated hundreds of miscellaneous alloy steels from the list of those that can be made, but has also impelled the development of new, reduced-alloy-content "emergency" steels (see our March issue, page 404), which may soon be the only types available for even essential engineering and machinery purposes. The "residual" nature of the alloy in these new steels suggests their ready adaptability to a concerted steel-industry program of all-out utilization of the residual-alloy content of today's "carbon" steels. In this article Mr. Reagan strongly urges such a program for maximum alloy conservation and discusses several practical factors—particularly the "quality" of alloy-bearing steel scrap—that will affect it.—The Editors.

A COMMON SUBJECT FOR DISCUSSION, whenever a few makers of steel congregate, is alloys—what our future requirements are to be; what our future specifications will call for; what our present residual alloy contents are: and, last but not least, how to obtain a supply of those alloys we are in need of.

It is interesting to note the wide difference in residual alloy contents of our present steels as compared with figures obtained about 10 yrs. ago:

	1931-1932		1942
	High	Aver.	High
Chromium	0.049	0.028	0.55
Nickel	0.107	0.037	0.50
Copper	0.215	0.077	1.00
Tin	0.041	0.010	0.77
Antimony	under 0.001		1.00
Molybdenum	under 0.001		0.15

The figures for 1931-1932 are those given by the U. S. Bureau of Mines in its study of residual metals, later continued by the Battelle Memorial Institute and after a few years discontinued. The figures are from some 18 different plants, a large majority of which were producing plain carbon steels. Data for similar conditions at the present time are not available but there is no doubt but that all are substantially higher.

The figures shown for 1942 are mostly from individual heats from a number of plants, all of which were making plain carbon steels (or hoped they were) and a number of different varieties of steel are involved. They are given to indicate the extremely high figures obtained in some heats by alloy contamination, and to show that substantial amounts of most of our important alloys are being used in materials in which they are of no economic value. Unfortunately we do not have available tonnage figures nor average alloy content based on monthly average figures, but when percentages of 0.55 Cr, 0.50 Ni and 0.77 per cent Sn are found in an occasional heat we may safely assume that the average is quite high. Incidentally, this would be a splendid opportunity for some Government agency (it could readily be resumed by the U. S. Bureau of Mines) to take up again the tabulation of residual alloys, by analyzing samples from the various plants for residual metals. In many cases this might be a tabulation problem only as a number of plants regularly analyze their steel for residual metals.

One of the reasons our residual metals are so high is that the steel maker has been glad to obtain any type of scrap with quantity rather than quality being the watchword. Under *present* conditions in the basic open-hearth furnace we have little opportunity to do anything about some of our valuable alloys and in this group are chromium, nickel, copper, tin, antimony, molybdenum, lead, zinc, and vanadium. Concentrations of lead, vanadium and zinc are believed to be as a rule quite small and whatever is received with the scrap is used and, with the exception of the amount oxidized or volatilized, passes on into the finished product. In certain sections of the country especial types of scrap containing

large percentages of various alloys are obtained in rather large quantities but in most cases it has been possible to identify these particular types of scrap and have them segregated.

It would be of value if the scrap dealers and the steel makers would pool their information about the various types of scrap containing alloys, etc. As an example of this are the figures given for antimony. One steel maker made three heats of steel, one containing about 0.15 per cent Sb, the second about 0.50 per cent and the third about 1.00 per cent Sb. The heat with the 0.15 per cent rolled satisfactorily but the other two containing 0.50 and 1.00 per cent were unsatisfactory and the material was scrapped. The source of the scrap containing the antimony was traced to the dealer and was found to be easily recognized once the material was known to contain antimony. Certain types of enameled ware have been found to contain antimony so that this material, if used in quantity will bear watching.

Die castings (zinc-base) often contain large amounts of tin, copper and antimony. Some contain as high as 15.0 per cent of antimony. Fortunately small tonnages are involved but one model auto contained over 100 lb. of die castings and this material can easily become a source of contamination. Recent newspaper information indicates that quite a large quantity of old refrigerator bodies are to be reclaimed and a scheme to pass this material through a sort of wringer arrangement to separate the enamel from the steel base is to be used.

Effect of Tin in Steel

One of the alloys that at present seem to be of considerable interest is tin. This is true both because there is an acute shortage of this metal, and also because its presence in steel is undesirable and in some cases has been of sufficient quantity to cause the rejecting of steel with too large amounts of it. It is not oxidized in the open-hearth furnace, and while it melts at about 231 deg. C. (450° F.) its boiling point is about 2,260 deg. C. (4100° F.), much too high to cause any loss in the open-hearth, so as a result whatever tin goes in with our open-hearth charge, is found in the final steel with no loss. Recent studies indicate that the carbon content of our steel aggravates the bad qualities of tin in steel. At 0.60 per cent C, contents of 0.03 to 0.08 per cent Sn gave trouble, but at 0.08 per cent C, tin contents as high as 0.20 per cent showed no ill effects.

The effect of tin depends very largely upon the carbon content. In tests on 0.10 per cent C, steel with 0.30 per cent Mn and with increasing amounts of tin added, it was shown that with 0.26 per cent Sn it is almost impossible to forge it and, when the tin content is over 0.40 per cent, it is red short. In one shop making low carbon steel a heat was found with 0.77 per cent Sn. A large part of the heat was rejected due to poor rolling qualities. Much tin scrap has been used (tin can, sheets, etc.) in the open-hearth and we have much to learn about the ill effects of too large a quantity of tin. Much of our tin covered scrap has been passed through an incinerator with the mistaken idea that such treatment removed the tin. We now know that only by chemical treatment can this important alloy be removed and recovered.

Another bad factor in the use of tin cans for steel scrap is the lead contamination from the seam. It apparently is a trouble maker in open-hearth bottoms. By a new process these cans are chopped up in small sections and both de-tinned and de-leaded. Careful control of the tin bearing material going into the charge and a constant watch on the percentage of tin found in the final product, and this factor tied in with defective material is the only solution for the open-hearth operator. Large quantities of this material have been used in the open-hearth and it would appear that proper segregation of tin containing scrap would pay large dividends in reclaiming sizeable quantities of this much wanted alloy.

Residual Manganese

Recent estimates indicate that reductions of 10 to 20 per cent Mn are possible in our manganese consumption. Most of the savings recommended are from the standpoint of reduced manganese contents in our specifications. Another factor, that has been too little stressed, is the ability to conserve manganese by slag control. In the lower carbon steel grades, little can be done along this line as these steels are normally made under high FeO slags and residual manganese is quite low; however some savings can be made by carrying these high FeO slags on the low side of FeO content. In the making of medium and high carbon steels, slag control can be an appreciative factor in savings of manganese and many times the over-all saving is greater than the saving in manganese alone.

The first factor controlling residual manganese in our steel is a high manganese content in our charge. Economically it does not pay to spend money for high manganese materials in the charge. If we can obtain them with no extra cost the slight increase in manganese is helpful. For a given manganese in our charge our residual manganese depends upon the FeO in our slag and our bath temperature, *i.e.*, the higher the temperature the higher the manganese and the lower the FeO the higher the manganese and manganese also depends upon the lime:silica ratio of our slag.

Larsen's recent fine paper indicates quite clearly that, with a lime:silica basicity ratio of 2.3 to 2.5, we obtain an optimum increase of manganese. By carry-

Adding a ladle of hot metal to an open-hearth furnace. (*Courtesy: Bethlehem Steel Co.*)

ing a low slag volume, a low FeO, and with the lime:silica ratio indicated, and by carrying as high a bath temperature as possible, we can obtain decided increases in manganese residuals. It is possible under ideal conditions to increase the residual manganese by 50 per cent or more, and increases of 30 to 40 per cent are common.

It can readily be noted that even with a manganese increase of 0.30 to 0.40 per cent on a 100-ton furnace, on forging grades of steel, substantial amounts of manganese may be saved. For example, aiming at 0.60 to 0.80 per cent Mn with a residual manganese of 0.40 per cent (and the use of a normal carbon block containing some manganese) an addition of 500 lbs. of ferromanganese is necessary. Under similar conditions a residual manganese of 0.30 per cent demands an addition of ferromanganese of about 800 lbs. or an increase of 60 per cent.

This decided increase in costs, in dollars and cents and a decided increase in pounds of manganese consumed can be taken care of by proper slag control. With proper slag and temperature control it is also possible to carry manganese in a much more narrow range. In other words instead of a specification of 0.60 to 0.80 per cent Mn, it is quite possible to make it 0.60 to 0.70 per cent and in one plant they shoot at 0.60 to 0.65 per cent and finish in that range a large part of the time.

Chromium and Nickel

These alloys will be considered together because they are usually found together, both in the scrap and in the product made in our open-hearth furnaces. Many times these alloys are combined with molybdenum or vanadium or both. The one serious defect to finding these alloys in combination is that in the electric furnace we can do little to separate them, or eliminate either as their recovery is almost 100 per cent. In the open-hearth we can oxidize the chromium and retain the nickel but, due to our chromium shortage, this is expensive business. Losses of chromium in the open-hearth, even under the most careful conditions, are high and expensive, and indicate why a much larger percentage of these steels will be made in the electric furnace where the oxidizing factors are low and recoveries at a maximum.

The data given at the beginning of this article indicate that large quantities of chromium and nickel bearing scrap have found their way into the open-hearth charge and have been used in the production of plain carbon (?) steels. Segregation of chromium and nickel bearing scrap is the only solution to this problem and it can be accomplished by the scrap dealer, probably at a nice profit. For example, a few years ago one of our most popular cars contained large quantities of chromium containing scrap. Some of the parts are shown below:

	Cr, per cent	
Driving pinion	0.65 to	0.80
Front axle	0.80	1.00
Connecting rod	0.80	1.00
Front wheel spindle	0.80	1.00
Rear axle	0.85	1.10
Rear leaf spring	1.00	1.20
Front leaf spring	1.00	1.20

With an average chromium content of about 1.00 per cent we would find in 10,000 tons of this material about 200 tons of chromium or the equivalent of 300 tons of ferrochromium containing 68 per cent Cr. Inasmuch as chromium is one of our most important alloys and the amount available strictly limited, this would seem to be an opportunity to increase our supply of chromium by segregating and using this type of scrap as chromium containing scrap and not as plain heavy melting scrap.

How much of this type of material is available is another problem but there is no question that there is a large tonnage possible, not only from old automobiles but from many other varieties of machinery, etc. When the origin of a piece of scrap is known, such as type of car, year, etc. analyses are quite a simple matter. When the origin is unknown other methods of simple analyses must be used. Many types of alloy containing scrap may be determined by the spark test. The spectroscope is another possibility for determining the analysis and last but not least, chemical analyses may be used. When the parts in question are manufactured in large quantities and each identical with the other, such as auto axles, etc., it remains only necessary to determine the analyses of one part.

As many of our specifications call for both nickel and chromium, we should do all possible to use this combination of alloys, by utilizing available scrap containing both of the alloys, and by making materials that can use to best advantage as much of each alloy as is of most economic value from the standpoint of natural residual alloys available in our scrap supply. If very large tonnages of this type of scrap are available it might pay to promote the use of materials containing these alloys. Many times we also find molybdenum with chromium and nickel and as it is not oxidized we obtain a 100 per cent recovery of it, either in the open-hearth or in the electric furnace. Obviously due to the slight loss of chromium in the electric furnace process, it will be to our advantage to make as much of our chromium containing steels as possible in the electric furnace.

Many varieties of alloy containing scrap are available—entirely too many to be discussed in an article such as this, but it would be extremely interesting to have an article published listing the many varieties of alloy containing scrap. Some have large percentages of chromium and nickel, others contain copper, tungsten, etc., tied in with various alloys, many of which we at the present time cannot use. For example, there are large quantities of grindings from stainless steel available, containing 18 per cent Cr and 8 per cent Ni, but contaminated with fine particles from the grinding wheels which must be considered before the materials can be used.

A Summary

Briefly then our alloy conservation program boils down to the following:

1. Segregate all alloy containing scrap, where the percentage of alloy content justifies such segregation, and use this material as alloy containing scrap.
2. Institute a program of slag and furnace control to obtain maximum benefits from furnace practice, both in the open-hearth and the electric furnace.
3. Change our specifications to use a minimum of essential alloys.
4. Use materials, at present on hand, but not usable, due to being tied in with other alloys, etc. Some of these combinations will no doubt need considerable study.
5. Study present steelmaking activities to determine where (in which plants) large quantities of essential alloys are found in plain carbon steels.

PART I

Desulphurization in the Open-Hearth

One might expect that the considerable improvement in the quality of open-hearth steel already effected through the study and application of slag control in recent years would be a sufficient accomplishment. If anything, however, the investigation of specific factors in slag control is becoming more and more widespread, which bodes well for the quality —and production-speed—of the "ordinary" carbon steels on which industry must henceforth increasingly depend.

In this article the authors—no strangers to these pages—report on the desulphurizing power (at equilibrium) of calcium silicate steelmaking slags as affected by their iron oxide contents. Their results show that iron oxide actually has a greater effect than any other factor on the desulphurizing power of a basic slag. —*The Editors.*

by FRANK W. SCOTT and T. L. JOSEPH

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IN A RECENT PUBLICATION[1] the authors described an experimental furnace developed to study reactions occurring in the basic open-hearth. This article presents the results of a study on the effect of iron oxide on the desulphurizing power of calcium silicates at equilibrium. The effect of temperature on this equilibrium is also given.

It is recognized that many chemical reactions occurring between the slag, metal and gas in the steel making process do not reach equilibrium on account of their slow rate. Some of the reactions, however, actually attain a state of equilibrium. An accurate determination of the equilibrium state of any chemical reaction gives the limits the reaction will eventually attain. The discussion in this paper is confined to the desulphurizing power of certain calcium silicates at equilibrium. The rate of the reaction itself is not considered.

Earlier Work—Slag Composition

Nearly all investigators [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17] are agreed that the basicity of the slag exerts a very powerful influence on its desulphurizing power. The calcium oxide in the slag is considered to desulphurize the metal according to the reaction,

$$1. \quad \underset{\text{(Slag)}}{CaO} + \underset{\text{(Metal)}}{FeS} = \underset{\text{(Slag)}}{CaS} + \underset{\text{(Slag)}}{FeO}$$

Von Jonstorff[2] was among the first to conclude that the sulphur distribution coefficient increased with increasing basicity of basic open-hearth slags. Kohler[4] arrived at the conclusion that the desulphurizing power of a slag was determined directly through the lime content of the slag, and that the role of other constituents, such as manganese oxide, was negligible.

C. Bettendorf and N. J. Wark[8] studied desulphurization with laboratory tests, and with plant data taken from basic open-hearth, induction and Heroult steel making furnaces. They reported that while lime was the principal factor in desulphurization, its action was greatly increased when a solvent, as fluorspar or bauxite was added. Schwerin[9] observed similarly that fluorspar reduced the viscosity of slags that otherwise would be too viscous to be worked. This increase of basicity, and activity, favored desulphurization.

Although a considerable amount of research has been done on the effect of lime on desulphurization and its qualitative value established, there are still no data by which its quantitative value can be estimated. Many studies of desulphurization have consisted of attempts to relate desulphurization solely to the lime content of the basic open-hearth slag. This neglects the fact that lime may be present not only as free calcium oxide, but also as silicates and as phosphate, as well as calcium sulphide and calcium ferrites. The influence of these and other variables have been neglected, and as a result, quantitative data on the effect of lime are meager.

All available data indicate that the presence of iron oxide in the slag retards the transfer of sulphur from metal to slag. It has been shown by many investigators [2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17] that when the metal bath is high in reducing power, due to carbon, manganese, or silicon, the iron oxide in the slag is reduced, and desulphurization promoted. Viscous slags that tend to build up in iron oxide retard the rate of desulphurization.

Trifonow and Mirew[8] have stated that the desulphurization of metal occurs as indicated by the chemical reaction,

$$2.\quad \underset{(Slag)}{2CaO} + \underset{(Metal)}{FeS} = \underset{(Slag)}{CaS} + \underset{(Slag)}{CaO \bullet FeO}$$

They came to the conclusion that lime was the principal factor in desulphurization, and that deoxidation aided desulphurization by making more lime available.

Recent experimental data obtained by Fetters and Chipman[16] show that iron oxide does not entirely stop desulphurization. Slags containing over 90 per cent iron oxides had sulphur distribution const nts of over 4, while the lime was negligible and the only basic constituent was 5 per cent MgO. Sulphur distribution constants of approximately 1, indicate much poorer results with slags containing 16 per cent iron oxide, and with lime-silica ratios over 1.

Effect of Temperature

The effect of temperature on the distribution of sulphur between slag and metal has never been clearly defined. Chipman and Ta Li[13] calculated, by means of thermodynamical data, the equilibrium constants for desulphurization by lime, manganous oxide, and magnesia. These results indicated that an increase in temperature would increase the desulphurizing power of these basic oxides. From a study of data obtained from basic open-hearth operation, Fetters and Chipman,[15] came to the conclusion that higher temperatures favor desulphurization. In a later report, Fetters and Chipman[16] concluded that the sulphur distribution ratio was insensitive to temperature between 1550 and 1650 deg. C. Their conclusions were based upon experiments with slags containing CaO, MgO, FeO, and SiO_2 melted on a carbon free bath of iron containing sulphur.

Joseph and Scott[17] reported that the desulphurization equilibrium constant increased from 0.91 to 9.33 as the temperature in the basic open-hearth increased from 2850 to 2995 deg. F. These conclusions were based on data obtained from the operation of basic open-hearth furnaces. Barrett, Holbrook, and Wood[11] determined the desulphurization equilibrium constant for a $CaO \bullet 2SiO_2$ slag in a laboratory furnace and found it increased from 0.0252 at 1560 deg. C. to 0.0365 at 1625 deg. C. Other investigators[7, 8, 10] have expressed the belief that desulphurization is increased by higher temperatures.

Cook[12] has shown that the reaction by which sulphur is eliminated with lime is nearly neutral thermally. C. H. Herty[18] found the reaction to be almost neutral thermally by calculation, but observed that higher temperature actually favored desulphurization. Von Jonstorff[2] reported that desulphurization was not influenced by temperature to any appreciable degree. It is believed by many investigators that the only influence of temperature is to increase the activity of the lime and to bring more lime into solution. A high temperature also gives a more fluid slag, thus tending to decrease the iron oxide, and in this way favors its desulphurizing power. In these ways, high temperature would aid desulphurization without affecting the fundamental reaction.

The review of literature indicates that actual equilibrium and apparent equilibrium have been confused. Tests taken before equilibrium is reached are more often a measure of the rate of reaction than of the actual equilibrium values. As most of the data available have been taken from actual basic open-hearth operations, it must be remembered that in steel-making a condition of equilibrium is seldom attained as the factors which determine that equilibrium are continually changing. During the melting and refining periods, the conditions of reaction tend to adjust themselves always in the direction of equilibrium, and this constant tendency is not interrupted by increasing temperatures or by changes in the composition of the slag caused by fusion of the slag constituents. This continuous tendency may, however, be interrupted by furnace additions, such as fluorspar, burned lime, iron ore, or bath additions such as ferromanganese, cold pig iron, or ferrosilicon, which may cause it to begin again from a new initial point. Tests taken from such a process would seldom represent equilibrium conditions.

Scope of Investigation

The program of research was outlined to determine the effect of slag constituents, silica, lime and iron oxide upon the distribution of sulphur between slag and metal. The effect of temperature upon this distribution was studied over the entire steel making range of 1550 deg. C. (2822°F.) to 1675 deg. C. (3047°F.).

As very basic slags, with lime-silica ratios over 2, have high melting points, the basicity of the slags was necessarily restricted to those which are molten between the temperatures 1550 deg. C. (2822°F.) and 1675 deg. C. (3047°F.). Simple slag systems were formed from mixtures of pure lime and pure silica in proper proportions to form one of the following silicates: $CaO \bullet 2SiO_2$; $CaO \bullet SiO_2$; $3CaO \bullet 2SiO_2$; and $2CaO \bullet SiO_2$.

To facilitate the melting of these slags, Fe_2O_4 was added in each case. All melts were made under an atmosphere of commercial nitrogen gas that was

Table 1.—Gas Analysis of Furnace Atmosphere

Constituent	*Per Cent*
Carbon dioxide	1.4
Oxygen	0.4
Carbon monoxide	2.7
Nitrogen (by difference)	95.5

passed slowly and continuously through the furnace, which was enclosed and held under a pressure of ½ to 1 in. of water pressure. The oxygen in this gas reacted with the graphite in the furnace to produce a gas of the analysis shown in Table 1. A sufficient number of tests, usually three, were made with slags of each basicity to determine the effect of temperature upon the distribution of sulphur between the slag and the metal.

The concentration of iron oxide in these slags was controlled through the degree of oxidation of the bath. Conditions were established to maintain three degrees of oxidation. For the most oxidized condition, Armco ingot iron was melted and no additions were made to the metal. In the case of the intermediate state of oxidation, amounts of silicon were added to maintain a residual silicon content ranging from 0.20 to 0.50 per cent. The amount of residual silicon varied due to changes in the amount of silicon consumed in the reaction,

$$3. \quad Si + 2FeO = SiO_2 + Fe$$

To eliminate practically all the FeO from the metal bath, it was saturated with carbon, the amount of carbon present being a function of the temperature. In addition to the deoxidizing effect of the carbon,

$$4. \quad FeO + C = Fe + CO$$

silicon was added to produce a gray or graphitized metal that could be drilled for proper sampling. Moreover, in the presence of carbon in the metal, substantial amounts of silica were reduced as follows,

$$5. \quad SiO_2 + 2C = Si + 2CO$$

The addition of silicon accordingly permitted a closer control of the basicity of the slag and assured a completely deoxidized metal bath.

Equipment and Methods Used

The experimental furnace and its preparation for making these studies has already been described.[1] All tests were made using a bath of Armco ingot iron as a base. Sulphur in the form of iron sulphide was added to the molten metal to raise the sulphur content to approximately 0.10 per cent. Very little sulphur entered acid slag. In order to study the distribution of sulphur between slag and metal, it was essential to have sufficient sulphur in the system so that the amount of sulphur in the slag exceeded the limits of analytical accuracy. A bath containing 0.10 per cent S met this condition.

After the bath was melted and had reached the desired temperature, it was rotated at 400 r.p.m. to form the metallic cup in which the slag-metal reactions were carried out. A briquette made of the powdered slag constituents necessary to form a slag of predetermined composition, was dropped into this cup and melted. As soon as the slag was molten, and the temperature checked, clock time was noted.

Early experimental work indicated that the desulphurizing reaction proceeded rapidly. As soon as the slag melted, it reacted vigorously with the metal and formed gases in sufficient volume at the slag-metal interface to move the slag from the center of the top of molten steel. After 5 to 10 mins., the reactions proceeded more slowly, and the slag rode quietly on the metal bath. A series of preliminary tests showed that equilibrium was reached in an hour. All tests were accordingly held for an hour. The experiments reported by Barrett, Holbrook, and Wood,[11] also indicated that equilibrium was reached at the end of an hour. Holding the test for 2 hrs. did not alter the equilibrium value reached in an hour.

To obtain data representing equilibrium conditions with respect to sulphur distribution between slag and metal, at a definite temperature, it was necessary to remove the slag from the surface of the metal. Moreover, it had to be chilled to prevent any change in composition. Tests indicated that if the slag were cooled in contact with the bath, the sulphur distribution between slag and metal would depend upon the temperature at which the slag and metal solidified and not the temperature at which the tests were made. Instant chilling of the slag and the freezing of the equilibrium was accomplished by drawing the slag into a graphite cup. This apparatus has been described elsewhere.[1]

Data Obtained

All of the experimental data, and the calculations for converting the slag analyses from per cent to mol fractions are not given, but a summary of the results will be presented. In the discussion, the following terminology will be used: The index of basicity, R, is based upon the molar concentrations of lime and silica; the sulphur distribution coefficient, or partition coefficient, is obtained by dividing the per cent sulphur in the slag by the per cent sulphur in the metal. The equilibrium constant, K_s, is calculated,

$$6. \quad K_s = \frac{\%S_{slag}}{\%S_{metal}} \times \frac{(FeO)}{(CaO)}$$

This use of the per cent of sulphur in this calculation is permissible due to the very small quantities of sulphur present, and the uncertainty as to how the

sulphur exists in the slag and in the metal. The total iron oxide and the total calcium oxide are expressed in mol fractions.

Due to operating difficulties, the tests were not made at even temperature increments. This required interpolation and extrapolation of experimental results to study and summarize all the tests made at different times. It was desirable to correlate various data at specific temperature levels, as follows: 1575, 1600, 1625, 1650, 1675 deg. C. When the experimental values of K_s were plotted against the temperature, a linear relationship resulted. From this, the values of K_s at any desired temperature were obtainable. Using the lime concentration obtained experimentally, and the values of K_s and (FeO) obtained by extrapolation or interpolation, the values of $\%S_{slag}/\%S_{metal}$ were obtained. These are shown in Tables 2 and 3, and Figs. 1 and 2.

Effect of Slag Basicity

The relationship of slag basicity to sulphur distribution coefficients with controlled oxidation of the metal bath will first be discussed.

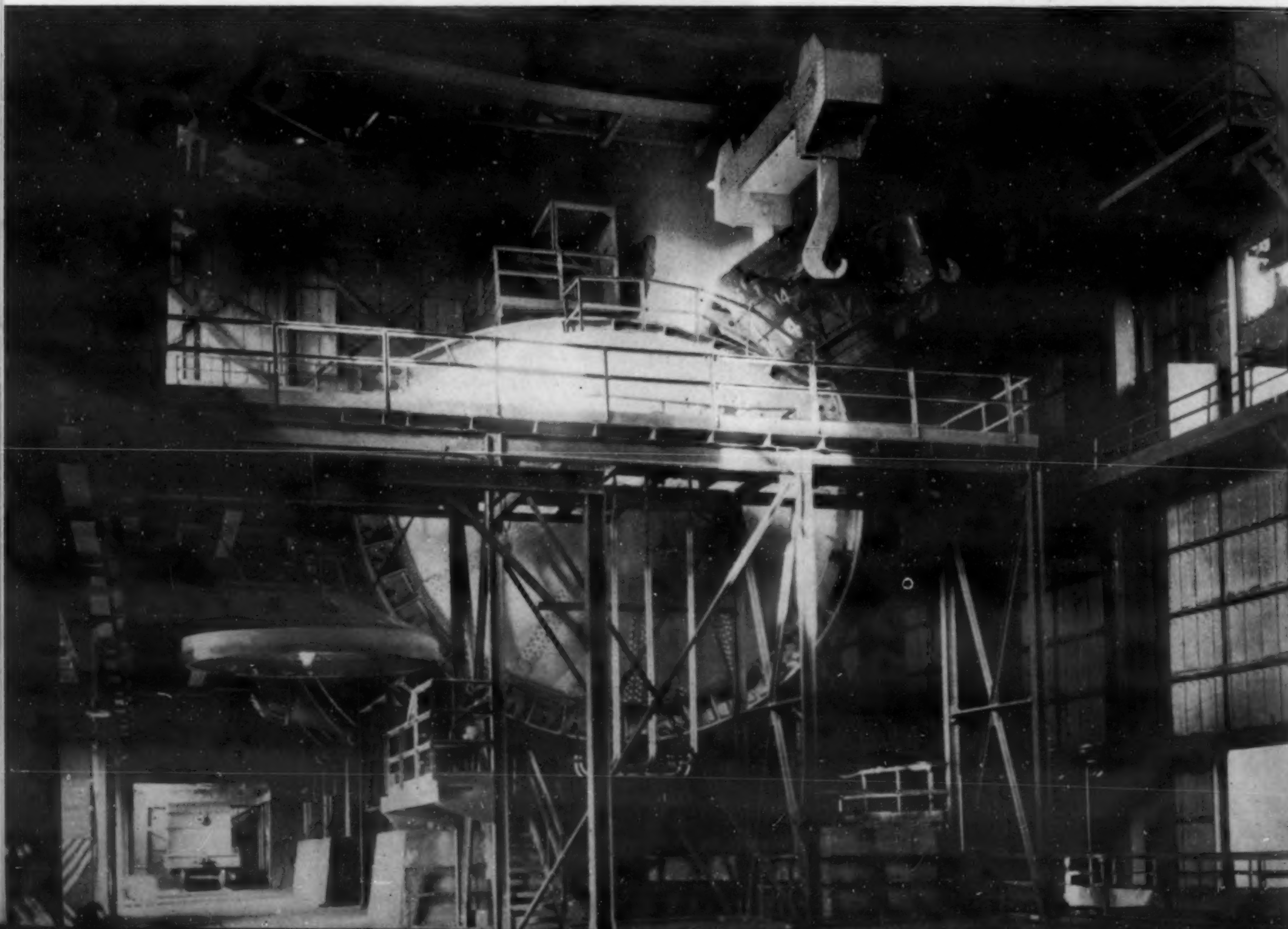
The desulphurization of steel by slag containing lime is considered to take place according to the equation,

$$7. \quad \underset{\text{(Metal)}}{FeS} + \underset{\text{(Slag)}}{CaO} = \underset{\text{(Slag)}}{CaS} + \underset{\text{(Slag)}}{FeO}$$

With a given concentration of FeS in the metal, it can be seen from the above equation that desulphurization is promoted by basic slags low in iron oxide. The concentration of sulphur in the metal is normally so small that the FeO formed by the above reaction is a very small portion of the total FeO in the slag. For a given slag at a given temperature, there is, at equilibrium a fixed relation between the concentration of FeO in the slag and the concentration of FeO in the metal. In the present series of tests, the weight of the metal was about 50 times the weight of the slag. It was feasible, therefore, to change the concentration of FeO in the slag by varying the degree of oxidation of the metal or the amount of FeO in solution in the metal

In these tests, the iron oxide in the slag was controlled by varying the amounts of carbon and silicon in the metal with the manganese being held between 0.025 to 0.050 per cent. In Part 1 of the series, the bath was oxidized, no silicon or carbon being added to the bath. In case of the intermediate oxidation in Part 2, silicon was added to the metal in such amounts that 0.20 to 0.50 per cent was retained as residual silicon. The analyses of the slags from these tests show that silicon was oxidized during the tests. Although the initial slag contained lime and silica in the same ratio as in Part 1, the final slags in Part 2, were more siliceous.

A hot-metal mixer, receiving part of its charge from a ladle. (Courtesy: Bethlehem Steel Co.)



In Part 3, the iron oxide in the slag was reduced to a very low level by saturating the metal with carbon, and by adding the equivalent of 1.00 per cent Si to the metal. These tests were difficult to make as the carbon in the metal reduced silica from the slag according to the reaction:

$$SiO_2 + 2C = 2CO + Si$$

In order to control the composition of the slags, it was necessary to make these tests at low temperatures to prevent excessive changes in silica. At the higher temperatures, the silica was so thoroughly and rapidly reduced during the course of the test that the melting point of the slag exceeded the temperature of the system. As the slag became very viscous, the rate of sulphur transfer from the metal to the slag was retarded or stopped. In such tests, significant equilibrium values were not reached.

In all the tests made and studied, the samples of slag removed from the furnace and instantly chilled, contained small spherical particles of steel or iron. These metallic particles were unlocked mechanically from the slag when it was ground for analysis. Each sample was carefully searched and all magnetic particles removed with a hand magnet.

It is probable that some of these metallic shot were oxidized on their surface during sampling. Most of them were, however, embedded in the slag so that the amount of iron oxide formed during sampling was small and could be neglected when the furnace slag contained substantial amounts of this oxide. In Part 3, however, the concentration of iron oxide in the slag was very low. Moreover, the slags worked within this part of the program were more viscous and contained more metallic shot. In spite of efforts to remove the contaminating iron formed during the sampling, these slags showed excessive and erratic amounts of iron oxide upon analysis. It was accordingly decided not to report iron oxide for Part 3.

The data given in Table 2 show the effect of the basicity of the slag, temperature and the degree of bath oxidation upon the distribution of sulphur between slag and metal. When R, the index of basicity, is less than unity, the effect of temperature as well as the degree of bath oxidation upon the desulphurizing power of the slag is small. However, when the value of R is equal to or exceeds 1.0, both temperature and the degree of bath oxidation have a pronounced effect. Under oxidizing conditions at 1600 deg. C., the values of the sulphur distribution coefficients range from 0.200 to 0.811 as the basicity index increased from 0.488 to 1.668.

Under strong reducing conditions at the same temperature, the values of the sulphur distribution coefficients range from 1.274 to 197.0 as the basicity index increased from 0.665 to 1.823. This tremendous change in desulphurizing power of the slags is

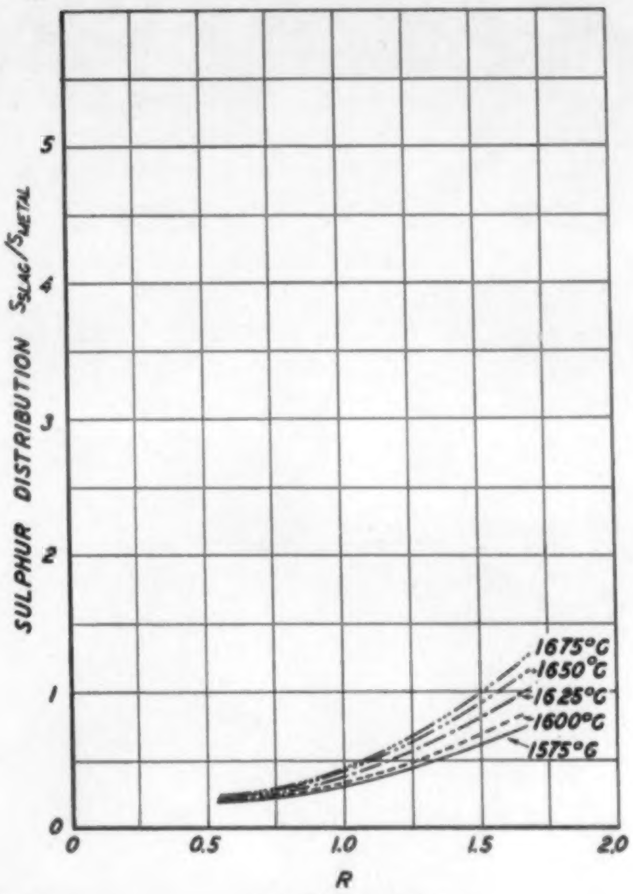


Fig. 1. Relationship of slag basicity to the sulphur distribution coefficient determined on an oxidized steel bath.

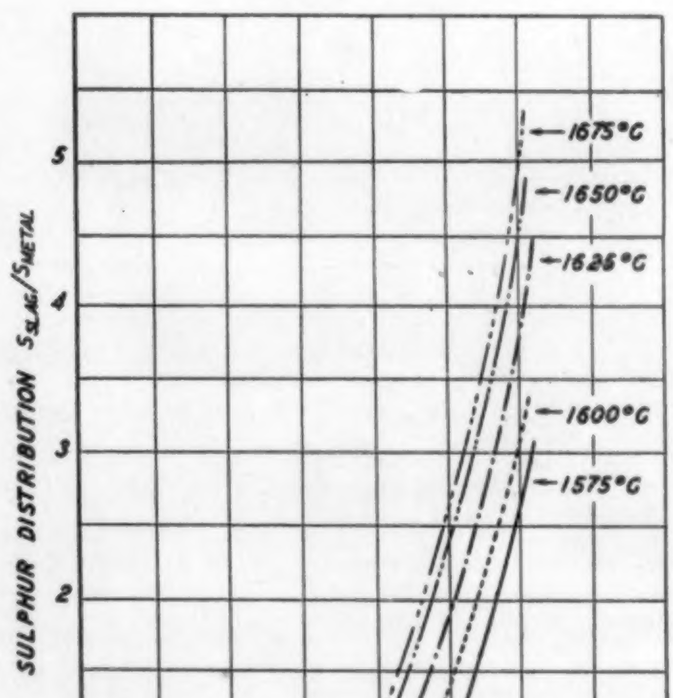


Fig. 2. Relationship of slag basicity to sulphur distribution coefficient on a silicon-deoxidized steel bath.

due to the comparatively small change in the amount of FeO in the slag. The desulphurizing power of the slags at 1600 deg. C. over a bath containing silicon was intermediate. Coefficients range from 0.227 to 3.680 as the basicity index increased from 0.381 to 1.584. The metal bath in this case represents an intermediate stage of bath oxidation.

The effect of the degree of bath oxidation is also shown in Figs. 1 and 2. The group of curves in Fig. 2, representing an intermediate degree of bath oxidation are much higher than those in Fig. 1 which represents an oxidized bath. This is particularly true when the basicity index, R, exceeds 1.0.

(To be concluded)

Table 2.—Relationship of Slag Basicity to Sulphur Distribution Coefficients at Various Temperatures.

Temperature Deg. C.	Part 1 Oxidized bath R	Part 1 Oxidized bath $\%S_s / \%S_m$	Part 2 Silicon-deoxidized bath R	Part 2 Silicon-deoxidized bath $\%S_s / \%S_m$	Part 3 Carbon-deoxidized bath R	Part 3 Carbon-deoxidized bath $\%S_s / \%S_m$
1575	0.539	0.230	0.479	0.227	0.466	0.406
1575	0.933	0.308	0.909	0.309	0.727	7.109
1575	1.250	0.692	1.372	1.867	1.148	28.40
1575	1.617	0.694	1.531	2.715	—	—
1600	0.488	0.200	0.381	0.227	0.655	1.274
1600	0.914	0.356	0.953	0.487	1.090	7.123
1600	1.332	0.665	1.237	2.043	1.418	40.30
1600	1.668	0.811	1.584	3.680	1.823	197.00
1625	0.508	0.223	0.381	0.252	0.625	0.338
1625	0.914	0.346	0.971	0.666	—	—
1625	1.312	0.745	1.264	2.234	1.412	19.30
1625	1.635	0.914	1.584	4.292	1.562	179.00
1650	0.508	0.243	0.502	0.303	—	—
1650	0.914	0.336	0.971	0.839	—	—
1650	1.312	0.775	1.264	2.400	—	—
1650	1.635	1.080	1.584	4.776	1.980	130.00
1675	0.508	0.263	0.502	0.315	—	—
1675	0.914	0.350	0.971	1.013	—	—
1675	1.312	0.805	1.264	2.523	—	—
1675	1.640	1.210	1.584	5.267	—	—

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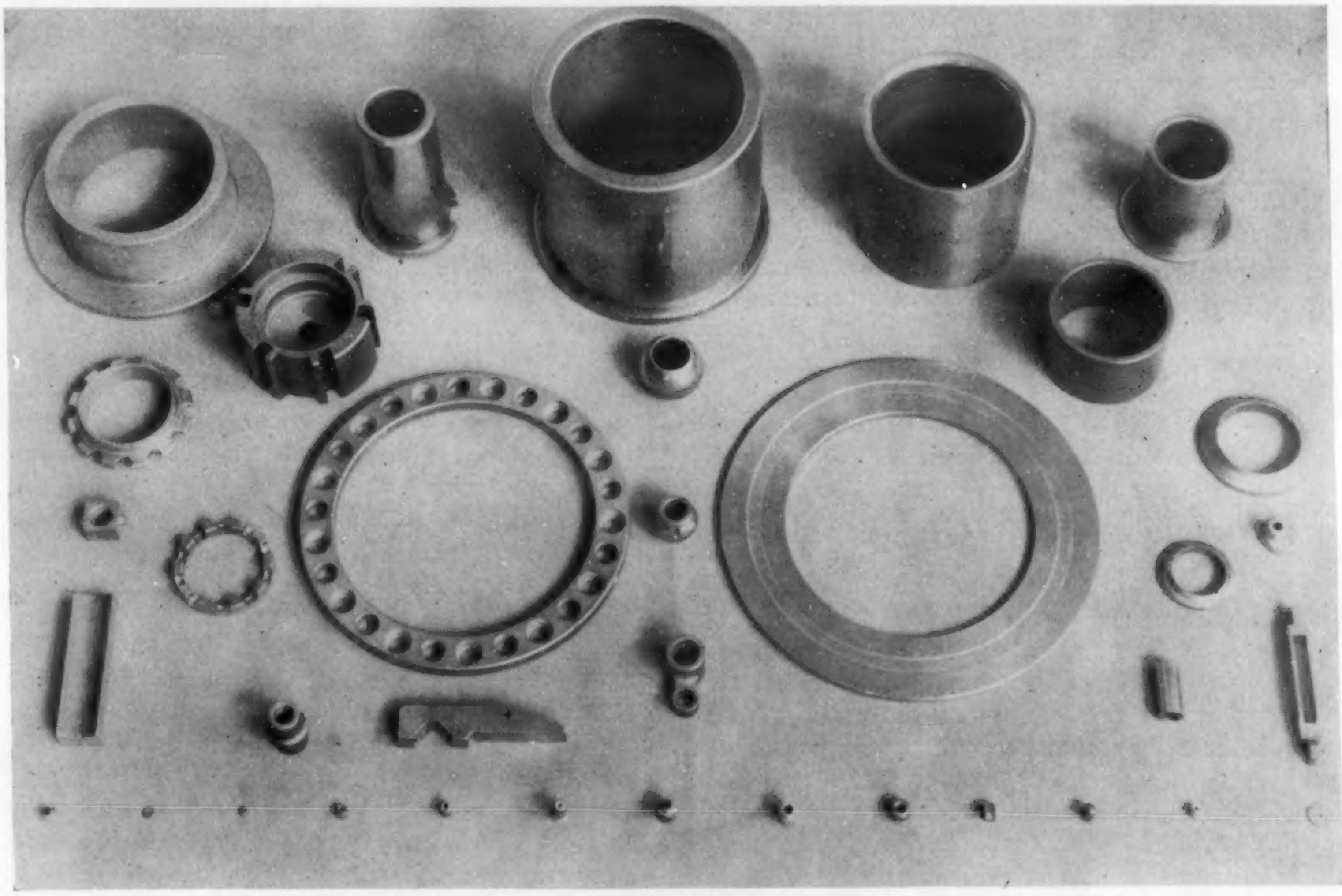
Powder Metallurgy of Tin

MANUFACTURE AND USES OF TIN AND TIN ALLOY POWDERS

Bronze powder metallurgy parts. Composition: 90 Cu, 10 per cent Sn with graphite in varying amounts up to about 6 per cent. (Courtesy: Metals Disintegrating Co., Elizabeth, N. J.)



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All the current interest in powder metallurgy as a fabricating operation may easily blind us to the fact that the true scope of "powder metallurgy" is much broader than just the manufacture of useful articles by pressing and sintering metal powders. Actually, the whole field of powder metallurgy includes the production of powders and their applications in a variety of ways—for decorative purposes, brazing, pyrotechnics, friction surfaces, etc.—as well as in fabrication. This article is a compilation of published information on this entire field as related to tin and tin alloy powders. A useful list of patents is included. —*The Editors.*

LITTLE OF VALUE has been published on the manufacture of tin powder as most of the processes are kept secret by the producers. The small amount of information that has appeared is not readily available and is scattered through a large number of technical papers. The main object of this report is to collect together the scattered data on tin and tin alloy powders with a view to obtaining a clearer conception of the methods by which the powders are prepared and the principal uses to which they are put. Many of the sections are far from complete but it is hoped to supplement these at a later date when the necessary information comes to hand.

A bibliography is appended which includes references to all of the important papers and articles which have been consulted in writing this report. A classified list of patents dealing with the manufacture and applications of tin and tin alloy powders has also been compiled, but the information from these has not been incorporated in the report. To the best of our knowledge, this list contains all of

the British patents concerned from 1915 to date. The list of American patents is complete from 1934 onwards and a number of earlier patents is also included. The other foreign patents referred to are those recorded in the files of the Bureau of Technical Information, but the list is very incomplete.

Manufacture of Tin Powder

The following three methods are quoted in the literature as being used for the production of most of the tin powder used commercially:

(a) Atomization
(b) Chemical precipitation
(c) Electrodeposition

Coarser tin "powders" may be made by (d) Shotting or Granulating and (e) by Graining.

Atomization: Atomization consists essentially in the forcing of a thin stream of molten metal through a small orifice and hitting this stream with steam or compressed air or gas, which distintegrates and solidifies the metal into finely divided particles of ragged "tear drop" shapes. In one application of this method, steam or compressed air that has been preheated to approximately the melting point of tin (232° C.) is directed through a nozzle (partly submerged in the molten metal) in such a manner as to draw the metal up through a tip that is inside the nozzle. By proper design and arrangement of the nozzle and tip assemblies, by adjustment of steam, air or gas pressure, and by varying the viscosity of the molten tin through control of the amount of superheat of the metal, the degree of fineness of the atomized product can be regulated over a considerable range. The atomized tin is carried off under suction to a dust-collection system such as a cyclone dust collector and baghouse.

Steam or compressed air might be expected to result in excessive oxidation, but this does not occur because of the rapid chilling effect of the expanding gases released through the nozzle. Tin, when atomized with compressed air, contains less than 0.2 per cent O as oxide. The thin film of oxide produced during atomization with steam or air is sufficient to prevent further oxidation of the powder.

It is possible to produce powder of a considerable range of fineness by the method just described, but for coarser powders that are required to contain a minimum of fines, the cross-jet method is better. In this a stream of molten tin is forced through an orifice, or is otherwise allowed to pour into a jet of steam or compressed air directed substantially at right angles to the stream of molten metal. The problem of dissipating the heat is greater with this method because of the slower cooling of the somewhat larger particles. A larger collecting system must be used.

Atomized tin is used for molding work of various kinds, e.g. in production of porous bronze bearings.

Chemical Precipitation: Tin powder is produced from stannous chloride solution by precipitating with scrap zinc. This process is sometimes used in the recovery of tin from tin plate scrap. The latter is heated with chlorine and the resulting stannic chloride distilled off, reduced to stannous chloride and the tin precipitated as a gray powder by means of zinc. This powder has a tin content of about 79 per cent and consists of very fine granules. Impurities include stannous chloride, ferrous chloride, zinc chloride and water.

Tin powder produced by this method is extremely fine and is used principally in coating paper and for molding work.

Electrodeposition: Although reference is made in the literature to the fact that tin powder is produced commercially by electrodeposition, no details are given regarding the electrolytes employed and the conditions of electrolysis which must be employed. It appears from the patent literature that an acid tin chloride solution is used but it has not been possible to confirm this. Very good powdered tin is also said to be produced by electrolyzing a solution containing about 4 oz. per gal. of tin perchlorate with a slight excess of perchloric acid.

In general, the acid electrolytes used for producing powders contain a relatively low concentration of the metal and a high concentration of acid as compared with electrolytes used for plating. A relatively high cathode current density is usually employed. Under these conditions, a loosely adherent, spongy deposit is produced on the cathode, which may be periodically removed by various means such as scraping and "rapping" devices, and to a certain extent by rapid circulation of the electrolyte past the surfaces of the cathodes.

It is important that the metal deposit on the cathode be removed at frequent intervals, because if it is allowed to build up, the surface area of the cathode is thereby increased and the cathode current density lowered to such an extent that the deposit becomes too coarse and tends to plate out. In order to ensure uniformity of particle size of the deposit, it is, of course, also necessary to control the temperature and composition of the electrolyte carefully. By changing the composition and temperature of the electrolyte, and particularly by varying the cathode current density, the fineness of the powder produced can be varied over a considerable range. Addition agents (e.g. glucose) may also be used to improve the uniformity of the powder produced or to modify the type of deposit to meet specific requirements.

The deposited powder must be thoroughly washed to remove all electrolyte, as even small amounts of salts left with the dry powder will cause rapid oxidation when exposed to the atmosphere. It is usually advisable, after thoroughly washing the pow-

der, to dry the sludge in a vacuum or inert atmosphere, keeping the powder from contact with air until it has been thoroughly dried and cooled to approximately room temperature. When the powder is to be used subsequently in wet products or processes using solder pastes—the drying process may be omitted.

Some powders are heated in an inert or reducing atmosphere after drying, which has a tendency to improve the keeping (non-oxidizing) properties of the powder and tends to increase its apparent specific gravity by partial knitting together of the particles.

The hardness of the particles may be varied by controlling the drying conditions. Soft powders are obtained by drying with alcohol or similar liquids, while hardness is increased by gas-drying at higher temperatures.

After washing, drying and rubbing, the powder is carefully separated into sizes by a series of screens and bolting cloths of closer and closer weave. The very finest particles are removed and classified by an ascending air current.

Powders finer than 250 mesh can be prepared in this manner, but the most important feature of the process is the fact that it is possible to work closely to specified screen analyses and loading weights. These powders are generally remarkably pure, free from oxide, and uniform in their characteristics and are well adapted to molding work.

Shotting: A relatively coarse and roughly spherical shot powder can be produced from tin by pouring the molten metal through a screen or through small orifices, allowing the globules to solidify as they fall in air and finally collecting them in water. The height of drop and size of orifice determine the size and shape of the particles. The water serves as a cooling medium and prevents agglomeration of the particles.

When the granulated products may be irregular in shape, the molten tin may be dropped directly into water. Finer particles may be made by directing a stream of compressed air or steam against a stream of the molten metal before it reaches the water.

Granulated tin is used principally for various chemical purposes.

Graining: A rather coarse tin powder, known as "grain tin," may be produced by heating a rod of somewhat impure tin to a temperature of about 200 to 220 deg. C. and then pulverizing the tin, for example by hammering. The fusible constituents formed by the impurities cause the tin to fracture at the grain boundaries. A brand of tin containing a relatively large impurity of lead is most suitable for this purpose.

Manufacture of Tin Alloy Powders

The methods of atomization and shotting or granulating described above can be employed also for the production of certain tin alloy powders, e.g. tin-lead solder powder. A number of other methods are also applicable, and these are as follows:

(a) Machining
(b) Pulverizing
(c) Agitation of the liquid alloy
(d) Sintering

Machining: This type of operation is used for the production of the relatively coarse alloy powders used in the dental trade. These are alloys of silver with copper, tin and zinc and are supplied in the form of filings ready to be amalgamated immediately before use. The quantity of the alloy produced is not so great as to make this rather crude method impractical from a cost standpoint, particularly since the rather excessive cost of the operation is not too great in relation to the cost of the alloy itself. Freedom of the powders so produced from extreme fines or "slimes" is partly responsible for the selection of this type of process for manufacturing dental alloy powders. The exact machining operation used depends entirely on the ingenuity of the operator in adapting commonly known machining operations to produce in the most efficient manner the size and shape of metallic particles required. A file held in the frame of a power hacksaw is commonly used for the production of dental alloy powders. The powders are graded by sieving, passed over a magnet to free them from iron contamination, and frequently aged at 100 deg. C. for some hours.

Pulverizing: Certain brittle copper-tin alloys can be ground to powder in ball or stamp mills. A preliminary crushing or "shotting" operation may be necessary to break the metal down to a size that can be conveniently handled by the grinder used for the finishing operation. Heavy stamps, jaw crushers, or gyratories are suitable for such preliminary crushing treatment.

Agitation of the Liquid Alloy: R. W. Rees (*J. Inst. Metals*, 1935, Vol. 57, pages 193-195) found that many lead alloys could be broken up into a coarse powder by simple agitation of the molten metal during solidification. Alloys of the following range of compositions have been successfully treated in this way:

	Per cent
Lead	50
Tin	16–20
Cadmium	10–30
Bismuth	0–50
Antimony	0–10

An alloy of lead 50, cadmium 30 and tin 20 per cent, and having a freezing range from 180 to 150 deg. C., was found particularly suitable.

If the molten alloy was poured into a wooden tray and shaken vigorously while it solidified, about 10 per cent of the material was found to pass 100 mesh. A finer powder was obtained by pouring the

molten metal into an iron mortar, preheated to a temperature about 10 deg. C. below the melting point of the alloy, and grinding vigorously while the metal solidified. The addition of a little graphite before grinding prevented the particles from sticking together. The yield by this method was about

40 per cent through 100 mesh
25 per cent through 200 mesh

The method finally adopted was to feed the pasty metal into an impeller-type disintegrator maintained at a temperature about 10 deg. C. below the solidus. The body of the mill was preheated, but once up to temperature the heat introduced with the hot charge was sufficient to maintain the temperature at the desired value. The shaft carrying the impeller blades was belt-driven at a speed of about 1500 r.p.m. When the machine was fitted with a metal screen with perforations 1/64 in. in diameter, the yield was:

All through	70 mesh
80 per cent through	100 mesh
30 per cent through	200 mesh

The product was discharged into a bag and then sieved through the appropriate screen, any over-size being returned to the heated hopper. The output of such a mill is about 2 cwt. of 200-mesh powder per day.

A method based on the same principle, which is particularly applicable to the production of small quantities of soft solder powder, is as follows:

> A ladle filled with the metal is taken from the melting pot and is allowed to cool until the alloy becomes pasty, stirring the metal constantly with a wooden stick. It is then quickly emptied into a strong linen bag, the upper part of which is twisted around until the metal fits tightly into the bottom section. If the metal is then beaten with a hard-wood hammer with smart quick taps, turning the bag constantly, it will fall apart and become a gritty powder within a few minutes.

Providing that the metal is poured into the bags at only a few moments before complete solidification, the bags will not be damaged considerably and may be used a large number of times. With too high a pouring temperature the powdered solder becomes dark, or even black, from the carburized particles of the bag. Hammering should be continued until the metal feels only warm to the hands.

Sintering: Bronze powder may be produced by sintering together copper and tin powders in the desired proportions and grinding the sintered cake to a powder.

The copper and tin powders are first intimately mixed and are then heated in a neutral or reducing atmosphere at a temperature below the melting point of the alloy to be formed. As the melting point of tin is approached, the tin commences to diffuse into the copper to form a bronze alloy, and as the temperature is then increased the tin and copper completely diffuse to form a uniform alloy of the composition represented by the proportions of tin and copper used. The product is a sintered "cake" which may be ground to a powder with little difficulty. Since the sintering temperature used must be above the melting point of tin in order to obtain complete diffusion of the metals within a reasonable time, the alloy must not contain too high a proportion of tin, otherwise the alloy will fuse to an almost solid mass.

Certain phosphor bronzes can be made by sintering together mixtures of powdered copper, tin and red phosphorus. These alloys cannot be conveniently pulverized when cast in the usual way.

Applications of Tin and Tin Alloy Powders

The principal uses at the present time are as a decorative medium, in the production of certain powder metallurgical products, particularly porous bronze bearings, and as a constituent of tinning and soldering pastes and powders.

Decoration

Tin Coated Paper: The tin powder used for this purpose is usually produced by the chemical precipitation method. An emulsion of the finely divided tin suspended either in a weak gelatine solution, or in alkaline casein is coated on to the paper which is then passed through steam-heated calendering machines. These dry out the water and burnish the tin surface giving the metallic appearance.

In the production of the tin-coated paper for electrical condensers—known as Mansbridge paper—the tin is deposited on zinc in earthenware containers, periodically collected, washed, mixed with an adhesive and spread on the paper. The paper is afterwards heavily calendered, with the result that a thin, electrically-continuous film of tin is formed on one side.

Paints and Pigments: Owing to the high price of tin compared with the metals commonly used as a base for metallic paints it is unlikely that tin powder will ever find extensive application in this field. When tin has been employed it has been added as a constituent of a rust-preventive paint or has been introduced in order to obtain a paint of special color. Thus a rust-preventive paint which appeared on the market a few years ago had as a base a powdered alloy of lead 83, antimony 13, and tin 2 per cent. A matt silver paint referred to in the literature had a powdered alloy of tin 96.46, zinc 2.30 and iron 0.03 per cent as a base.

Powder Metallurgy Fabrication

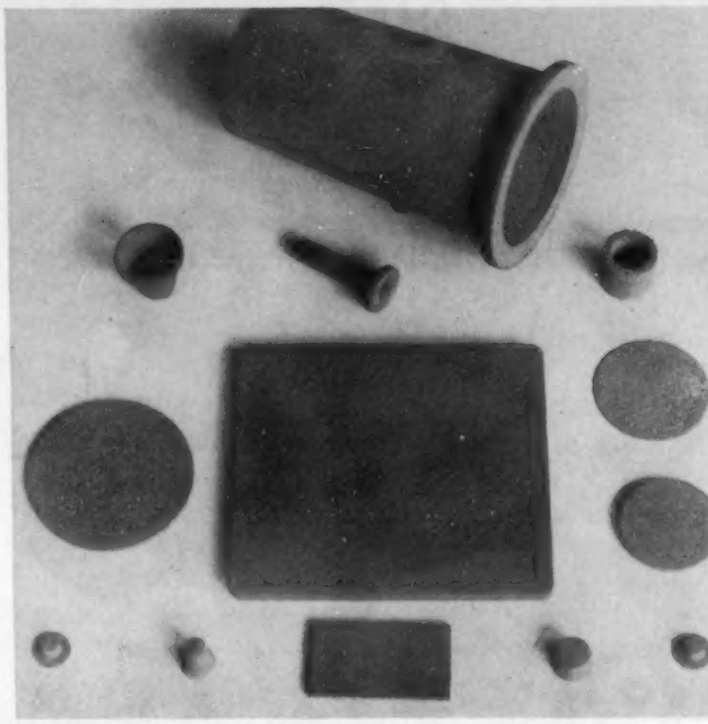
Bronzes: Bronzes made from copper and tin powders have a uniformity of composition unapproachable by foundry methods. This is very important for

electrical bronzes, and for this reason the powder method has been used for making certain special bronze parts for use in telephone apparatus.

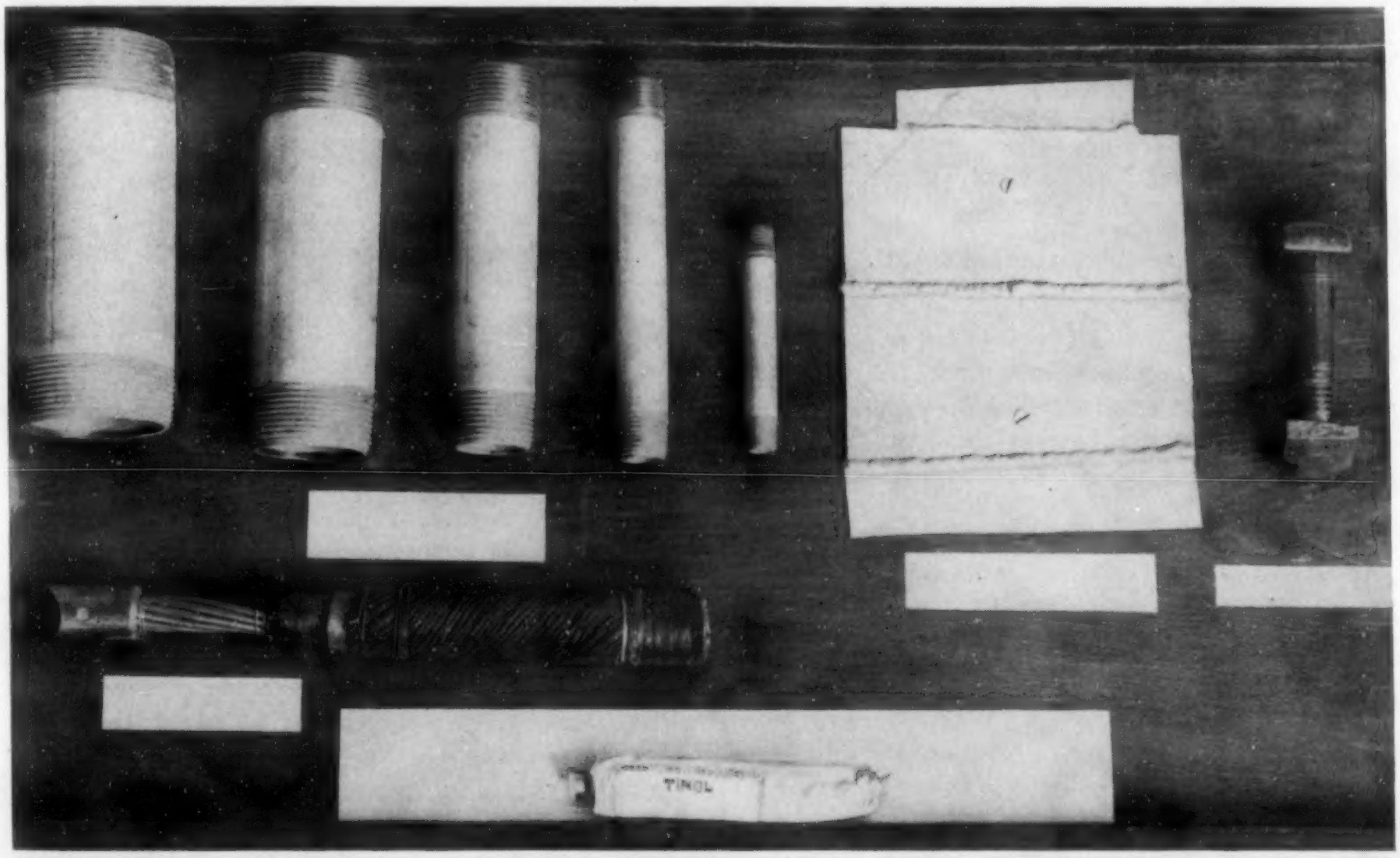
The tin and copper powders must be very thoroughly mixed if a homogeneous and uniform product is to be obtained. For this reason the powders are generally mixed in tumbling mills or continuously sieved for a long time—from 1 to 24 hrs.—so that each particle of one metal can get close to each particle of the other. Often the mixing operation takes place in a mill or tumbler in a hydrogen atmosphere.

After mixing, the powder is filled into a mold of the desired shape, squeezed so that it coheres, and the pellet heat treated so that the particles weld together at the contact points.

Since the metal particles should be as pure as



Bronze filters. (Courtesy: Metals Disintegrating Co., Elizabeth, N. J.)



Applications of solder powders and powder pastes for soldering and galvanizing. Note: On pipes and welded sheet, the bare steel (from cutting threads and from welding) are coated with powder compositions. Nut is locked to bolt with solder (applied in powder paste form). (Courtesy: Metals Disintegrating Co., Elizabeth, N. J.)

Diamond impregnated grinding wheels. Diamonds bonded in bronze composition matrix. (Courtesy: Metals Disintegrating Co., Elizabeth, N. J.)

possible (in order that the properties of the fabricated shapes may be highly uniform), tin and copper powders produced electrolytically are very suitable for this purpose.

Porous Bronze Bearings: A representative bronze used in the form of porous bearings contains 84.6 per cent Cu, 9.4 per cent Sn and 6.0 per cent graphite. The graphite is added largely for mechanical reasons, and the choice of powder metallurgical technique is made for the two-fold purpose of evenly distributing this graphite and for attaining a porous structure. Porosities varying between the general limits of 0.5 to 40 per cent can be obtained at will with this technique. Sometimes the porosity is artificially increased by mixing with the powders some volatile salt which volatilizes during heat treatment. This porosity is desired for the following reasons:

(a) To improve the mechanical performance of the bearing.

(b) To act as a reservoir for lubricating oil, with which the bearing is impregnated by the manufacturer.

(c) To provide a device independent of extraneous mechanical means for continually supplying oil to the working surface. This is achieved because of the intercommunicating nature of the pores, their great number and small size. These pores thus function as a great number of capillary tubes, the oil rising therein to manitain oil contact with the working surface.

Representative samples of copper and tin powders and graphite extensively used by bearing manufacturers have the following characteristics:

Method of Preparation	Copper Powder Reduction of Oxides	Tin Powder Atomization	Graphite
Screen Analysis: Mesh	Per Cent	Per Cent	Per Cent
+ 150	Trace	Nil	0.1
— 150 + 200	10.2	0.8	0.8
— 200 + 250	4.0)		
	)		
— 250 + 325	15.3)	(1.6	4.0)
— 325	70.5	97.6	95.1

Particle size distribution as determined by microscopic count:

Microns	Copper Per Cent	Tin Per Cent	Graphite Per Cent
0—5	0.5	27.1	1.2
5—10	4.2	30.5	14.8
10—20	20.7	24.5	19.3
20—30	18.4	11.6	16.2
30—40	16.2	2.6	25.6
40—50	10.5	1.3	18.0
50—75	18.3	1.4	4.0
75—100	10.2	1.0	0.8
+100	1.0	Nil	0.1
Apparent Density (or loading weight)	2.50	2.90	0.30

The powders are well mixed in the cited proportions and the loose mixture is pressed into the form of a sleeve. The compact is then heat treated and afterwards quenched in oil.

The bearing may be formed by feeding the mixed powder to a mold in an automatic briquetting machine and compressing, using a pressure of about 40,000 to 60,000 lbs. per sq. in. The coherence of the metallic particles is such that the bearing may be handled with considerable freedom. Heat treatment may consist merely in dipping the compacts into a cyanide pot or in sintering, for example at 810 deg. C. for 30 mins., in a neutral or slightly reducing atmosphere. In either case the time and temperature of treatment are regulated so that there is a true welding action at the multitude of points where metal comes into contact with metal.

Bearings may be impregnated with oil by quenching them in lubricating oil and allowing them to remain in the oil until the capillary pores are completely filled, or by a process of vacuum impregnation. The amount of oil which can be absorbed obviously depends upon the specific gravity of the metal mass, and this is regulated by the particle size of the constituent powders and the pressure. Very satisfactory bearings for heavy duty contain from 30 to 40 per cent oil by volume.

Sizing is most important in connection with the manufacture of porous bronze bearings and in this case it appears to be possible for sintering to take place with little or no alteration in external dimensions. Little is known about the conditioning factors of shrinkage and the control of it in the manufacture of bronzes is largely an empirical matter. For example, some manufacturers of this class of alloys have a decided preference for copper powder prepared by an electrolytic process, and this preference is largely connected with the shrinkage characteristics of this powder.

Shrinkage can be controlled to some extent by the addition of volatile substances to the pressings. The stearin and graphite which may be added to copper-tin powder mixtures for the purpose of producing porous bronzes undoubtedly has some influence in this direction, although stearin is mainly there for facilitating pressing. Electrolytic copper powder, such as is employed for the manufacture of this type of bearing, frequently contains appreciable quantities of carbonaceous residue insoluble in nitric acid. It has been shown that this substance has no appreciable influence on shrinkage.

Porous bronze bearings are mainly employed as follows:

(a) Where the bearing does not require much oil and the amount absorbed is sufficient, as in motor spring shackles.

(b) To regulate a gravity supply of oil to journal bearings. These then approach closely the efficiency of the best ball and roller bearings, and give a low coefficient of friction for starting up.

"Oil-less" bearings have been installed for several years in small electric motors for fans and other equipment when expert care cannot be assured. Electric clocks and domestic refrigerators have also used great quantities of them. One of the leading automobiles employs nearly a hundred porous bronze bearings in spring shackle bearings, steering gear bearings, clutch pilot bearings, chassis spring inserts, generator bearings, and water pump bearings.

Tinning and Soldering Pastes and Powders

Tinning powders consist essentially of pure tin powder intimately mixed with about 50 per cent powdered flux, usually ammonium chloride. Such powders are sometimes used for the tinning of cast iron and also for tinning other metals when the normal methods cannot be employed. The powder is spread over the heated metal surface to be tinned and is then wiped until an even coating is obtained. Once the metal has been tinned, the thickness of the coating may be increased by melting on tin from a stick and wiping it as before.

Soldering pastes facilitate soldering by combining the solder and flux in one preparation. They usually consist of powdered tin or solder mixed with zinc chloride and ammonium chloride, glycerine and water. The percentage of flux may vary between about 10 and 50 per cent. Some typical analyses of solders which may be purchased in this form are given in the Table.

Table of Typical Analyses of Solders

Type	Aqueous, water-miscible	Dry, water-miscible	Aqueous, water-miscible	Aqueous, water-miscible	Organic wax-oil paste
Solder composition, percentage					
Tin	100.0	100.0	67.0	43.0	49.0
Antimony	Nil	Nil	Nil	0.2	Nil
Lead	Nil	Nil	33.0	56.8	51.0
Total	100.0	100.0	100.0	100.0	100.0
Percentage of flux	50.0	40.0	14.5	10.0	19.0
Flux composition, percentage					
Zinc chloride	23.5	Nil	Nil	Nil	32.0
Ammonium chloride	66.5	100.0	18.5	20.0	Nil
Glycerine	Nil	Nil	56.5	71.0	Nil
Water	10.0	Nil	25.0	9.0	Traces
Hydrocarbon wax	...	...	...	...	50.0
Paraffin oil	...	...	...	...	18.0
Total	100.0	100.0	100.0	100.0	100.0

Samples Nos. 3 and 4 are said to be very satisfactory in practice, while No. 5 has been found somewhat unsatisfactory owing to the difficulty of avoiding dirty joints.

List of Patent Literature

	British Patents	U. S. Patents	French Patents	German Patents	Other Patents
MANUFACTURE:					
Tin powder	124,006	1,365,140	415,760	88,273	
	173,605	1,799,157	550,891	584,453	
	253,958	1,977,173	788,358		
	282,112				
	303,984				
	391,839				
	443,450				
	497,586				
	497,610				
Tin alloy powders	158,740	2,037,672	761,496		
	163,809	2,076,798			
	226,286				
	283,488				
	386,499				
	438,552				
	442,773				
	506,432				
	506,433				
APPLICATIONS:					
Porous bronze bearings	210,063	1,479,859	715,478	624,978	
	214,580	1,642,347			
	216,484	1,642,349			
	230,806	1,916,338			
	270,271	1,927,626			
	275,444	1,930,287			
	280,497	1,937,465			Canadian Patents
	284,532	1,958,740			
	306,129	1,974,214			373,492
	330,577	1,979,498			
	364,546	1,980,540			
	365,068	2,075,444			
	464,727	2,097,671			
	464,920	2,132,867			
	470,133	2,133,761			
	488,590	2,168,227			
	492,618	2,168,300			
		2,168,301			
		2,178,529			
Bronzes	485,565	1,922,402	759,367		
	503,874				
Dental alloys	283,488		761,496		
	442,773				
Miscellaneous tin alloys	132,261				
	477,572				Russian Patents
	484,996				
Paints and Pigments;	225,072	1,421,471		437,502	43,791
Protective and other coatings	261,017	1,939,667			
	300,060	1,980,670			
	331,863	2,032,845			
	385,310				
	410,407				
	431,641				
	474,064				Russian Patents
	477,451				
Miscellaneous applications	339,645	1,980,016			37,208
	392,067	1,998,144			Austrian Patents
	464,632	1,992,548			
					143,949

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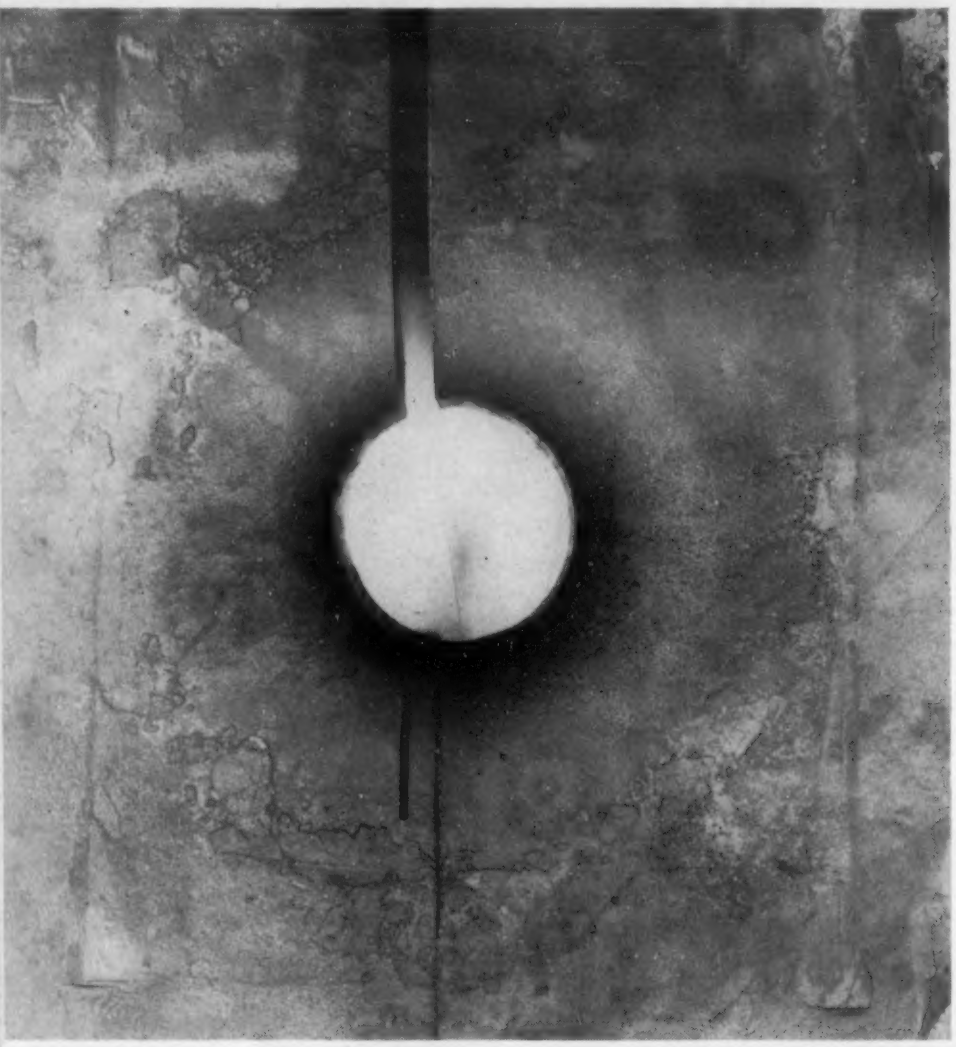
"Sintering of Copper and Tin Powders." H. E. Hall. *Metals and Alloys*, Vol. 10, Oct. 1939, pages 297-298.

Fig. 9. Surface of forge test specimen, 1/2 natural size, of low copper steel. Specimen 12 in. by 12 in. by 1 1/2 in. with center hole 1 1/4 in. diam. Soaked at 2,000 deg. F. for 1 1/4 hrs., 3 in. diam. ball subsequently driven through center hole in plate. Note smooth appearance of most highly stressed surface zone at the base of center hole.



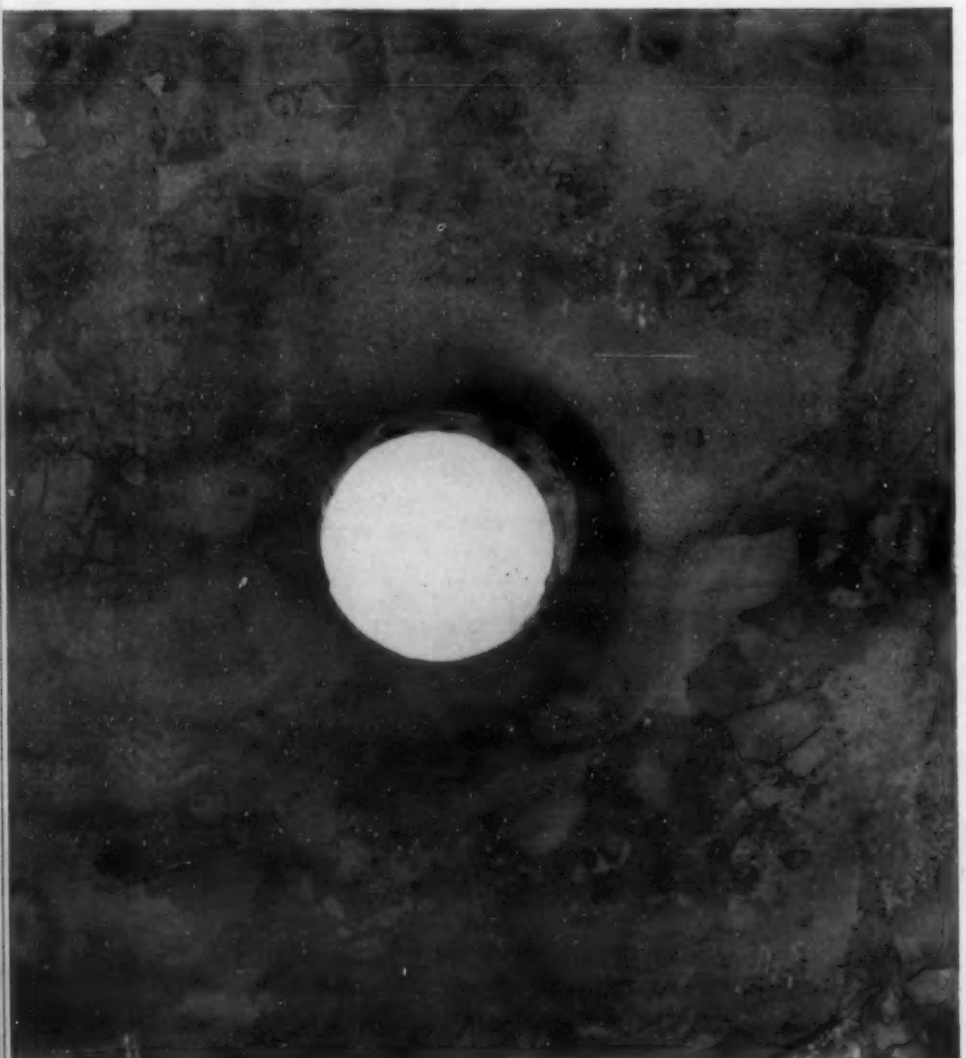


Fig. 10. Surface of forge test specimen, 1/2 natural size, of copper-bearing steel (0.26% Cu). Specimen 12 in. by 12 in. by 1 1/2 in. with center hole 1 1/4 in. diam. Soaked at 2,000 deg. F. for 1 1/4 hrs., 3 in. diam. ball subsequently driven through center hole in plate. Note numerous small surface tears in most highly stressed zone near the base of the center hole.

Copper-Bearing Steel

by F. EBERLE

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The first instalment of this article, published in our April issue, reviewed the problems involved in forging, hot-rolling, hot-forming and welding copper-bearing steels. In this concluding instalment, the causes of surface-cracking are further examined and some "cures" discussed. —*The Editors.*

Forging Properties Under Normal Conditions

The behavior of the copper-bearing plate under normal forging conditions, as encountered in the fabrication of drum heads, was studied by a forging test which reproduced the principal hot working conditions of drum head forging. For comparison, the same test was made with a low copper high tensile plate, analyzing:

C	Mn	Si	P	S	Cu	Ni
0.31	0.61	0.17	0.028	0.023	0.09	0.005

The testing procedure was as follows:

Two test plates, 12 by 12 by 1 1/2 in. with a 1 1/4-in. hole in the center, were heated to 2000 deg. F. and held at this temperature for 1 1/4 hrs., which is approximately the soaking time employed for the plate thickness in question under fabricating conditions. The furnace temperature was measured by means of a thermocouple and portable potentiometer. After removal from the furnace, a 3-in. dia. steel ball was driven through the 1 1/4-in. hole in the center of each plate. This operation was finished at a temperature of 1600 deg. F. (measured with an optical pyrometer).

Fig. 9 and 10 show the surface of the low copper

el

for Heavy Fabrication—II

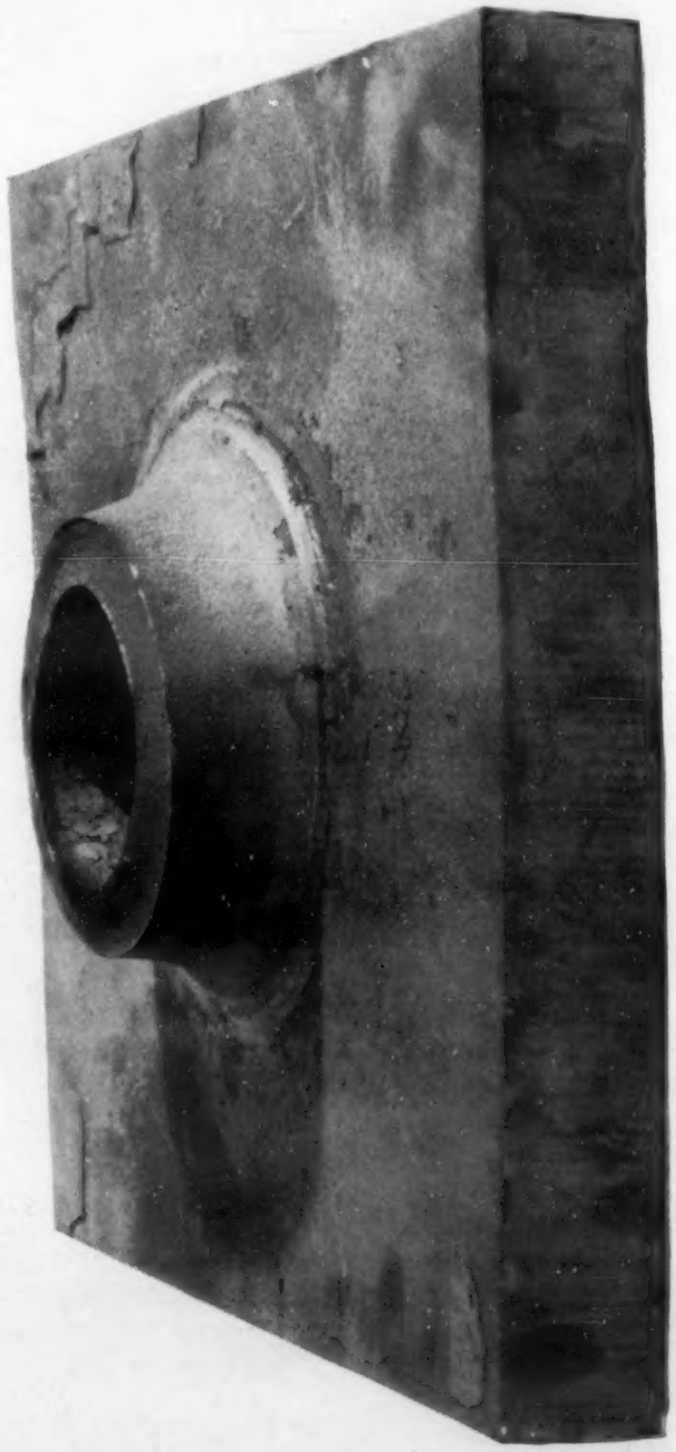
—Avoiding Surface Cracking

and the copper bearing test plate, respectively. The underside of the latter is depicted in Fig. 11. A comparison of the surface of the copper-free plate with that of the copper-bearing plate shows that the latter displays suspicious looking tears in the surface zones which had undergone the greatest deformation. These surface check marks are absent in the copper-free steel (see Fig. 9). Macro-etched cross sections through the two test plates, (Fig. 12 and 13), revealed that the surface tears or check marks of the copper-bearing plate were confined to a very thin surface layer. Slightly enlarged cross sections through the most highly deformed surface zones of the two test plates are shown in Figs. 14a and b. It will be noticed that the surface of the low copper steel is smooth, whereas that of the copper-bearing plate contains a multitude of shallow round-bottomed openings. Additional illustration of this phenomenon is presented by Figs. 15a and b, which depict the micro structure of cross sections through the most highly deformed surface zones of the two test plates.

The conditioning effect of the 2000 deg. F. anneal upon potential surface tearing during subsequent hot forming operations was studied with two cubes, 1 in. by 1 in. by 1½ in. of low copper and copper-bearing steel. These two test cubes were annealed together with the previously described test plates. The microstructures of cross sections through the surface of the two test cubes are presented in Figs. 16a to d. The surface tearing observed in the copper-bearing steel after prolonged heating to 2000 deg. F. appears to be absent in the sample which was annealed for only 1¼ hrs. However, a slight surface roughening is discernible in the latter, while the surface of the low copper steel seems to be smooth.

The comparative forging tests indicate that the higher copper containing steel plate can be successfully forged into drum heads, provided the temperature range of forging is maintained within prescribed limits and also provided that the soaking time prior to the forging can be kept below a certain maximum value. Even under these conditions, a roughening of the hot deformed surface is to be expected, which may lead to rejection of otherwise perfectly sound material.

Fig. 11. Underside of forge test specimen, ½ natural size, of copper-bearing steel (0.26% Cu) depicted in Fig. 10. Picture indicates the severe stretching of the metal on the surface of the specimen.



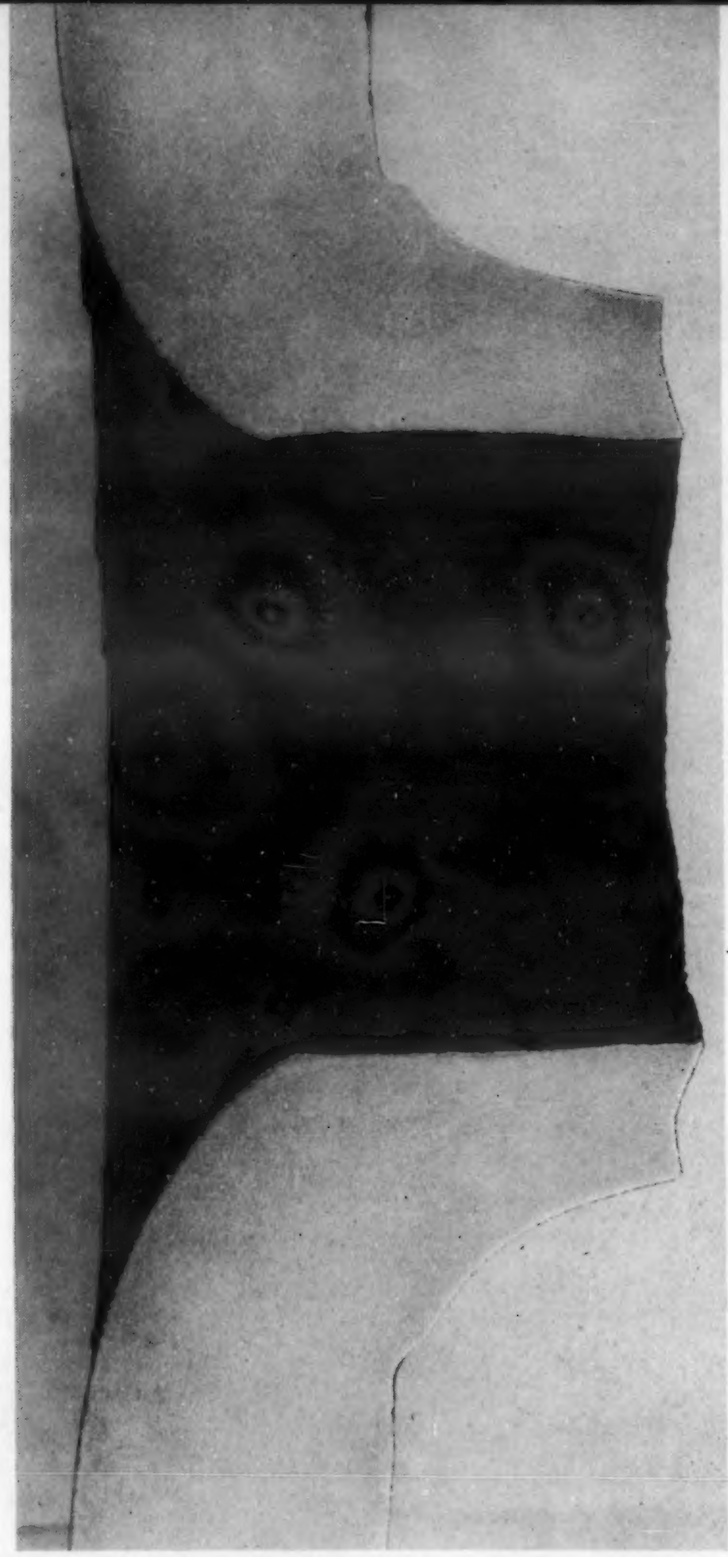


Fig. 12. Macro-etched cross section through forge test specimen of copper-bearing steel (0.26% Cu) depicted in Fig. 10. Note surface tears visible in Fig. 10 are confined to a very shallow surface zone.

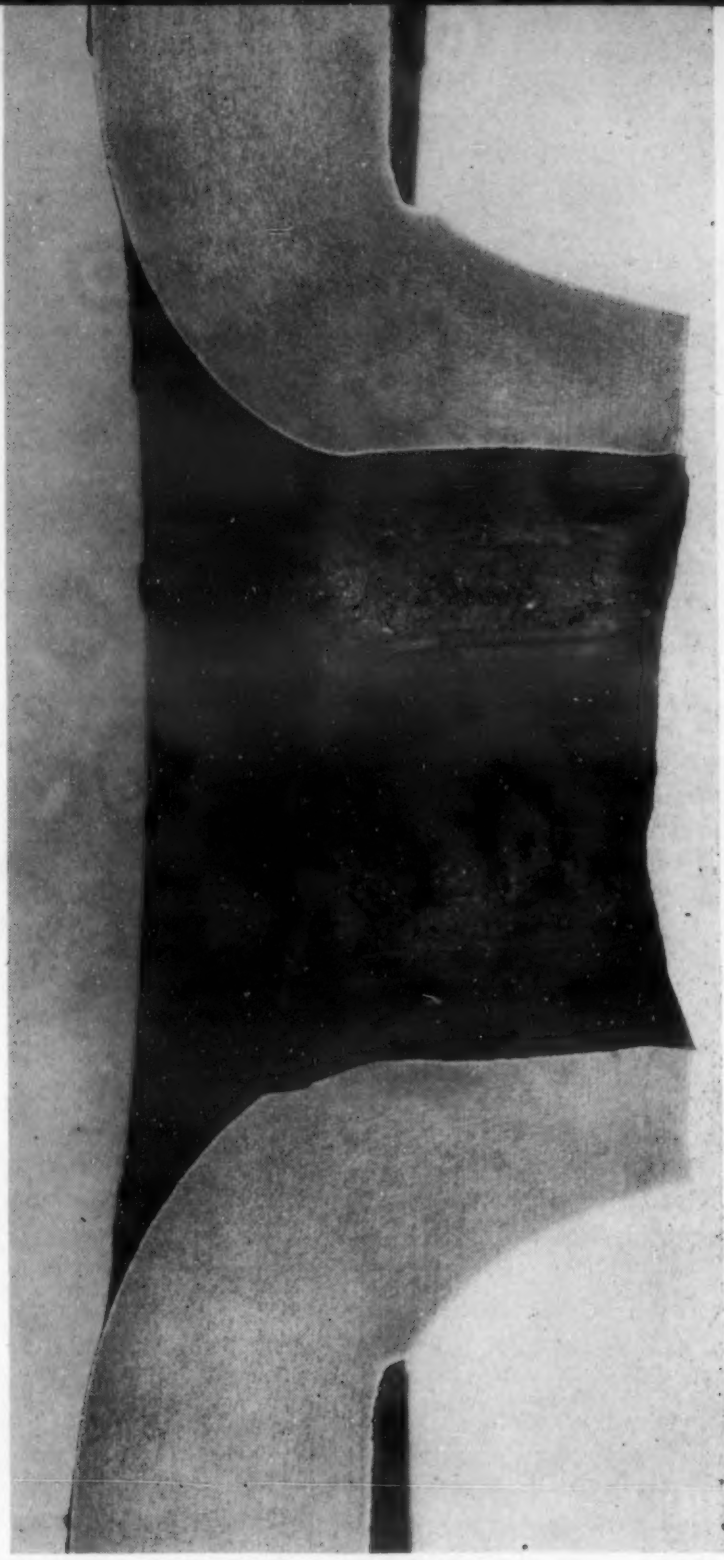


*Fig. 13. Macro-etched cross section through forge test specimen of low copper steel depicted in Fig. 9. **Note absence of surface roughness.***

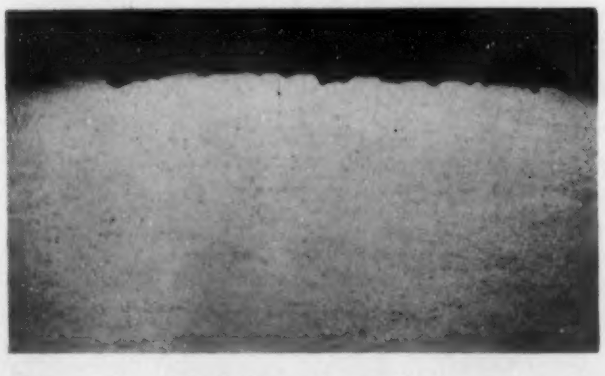
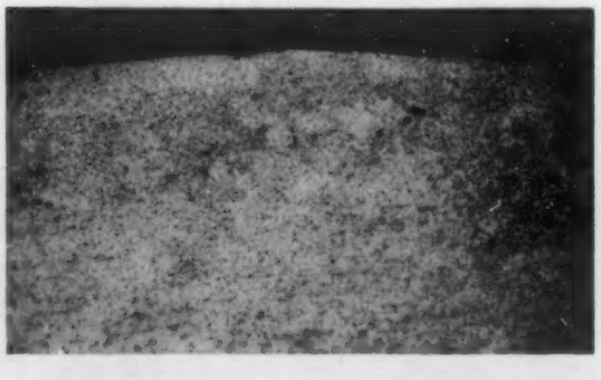


Fig. 14a. Slightly enlarged cross section through most highly stretched surface zone of forge test specimen of copper-bearing steel (0.26% Cu) depicted in Fig. 10. Note shallow surface tears.

Fig. 14b. Slightly enlarged (mag. 4X) cross sections through most highly stretched surface zone of forge test specimen of low copper steel depicted in Fig. 9. Note smoothness of surface.



Effect of Structure Upon Red-Shortness

In the course of the investigation it was noticed that the copper-bearing steel displayed carbide coalescence in the grain boundaries (Fig. 17). The reduced ductility associated with this condition explains the red-shortness which had been observed in these copper-bearing steels above the lower transformation point. It also explains the extreme degree of fissuring which occurs in this steel when forging is continued into the temperature range of red shortness (approximately 1350 to 1500 deg. F.).

Discussion

It has been again experimentally demonstrated that steel with a copper content of about 0.25 to 0.30 per cent shows preferential surface oxidation of the

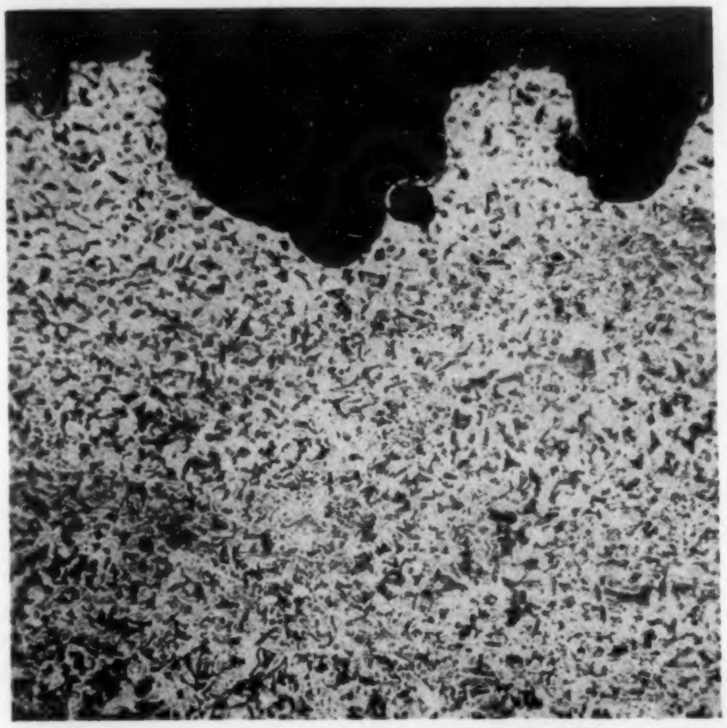


Fig. 15a. Cross section through the most highly stretched surface zone of the copper-bearing forge test piece depicted in Fig. 10. The surface tears visible in the latter appear as shallow round-bottomed surface openings. Etched with nital. 50X.

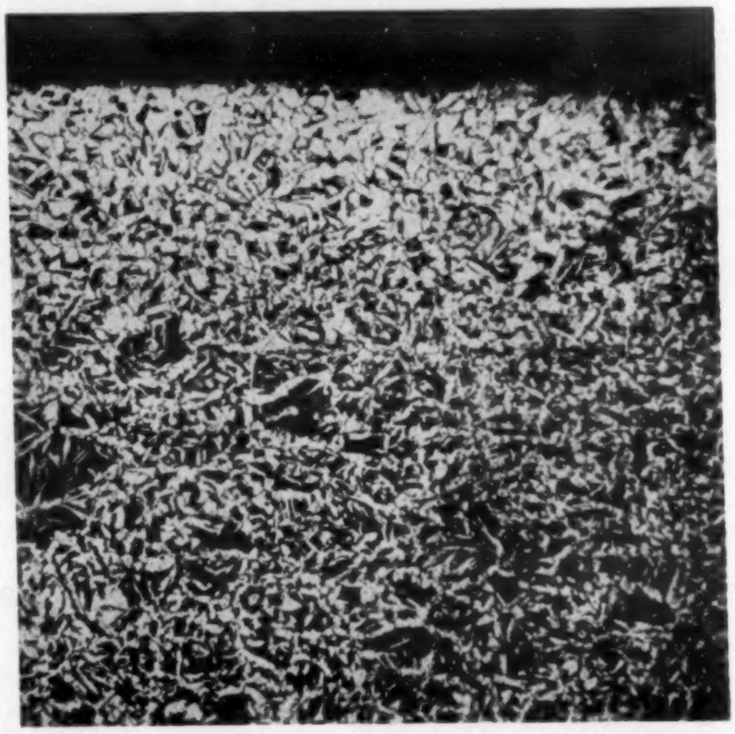
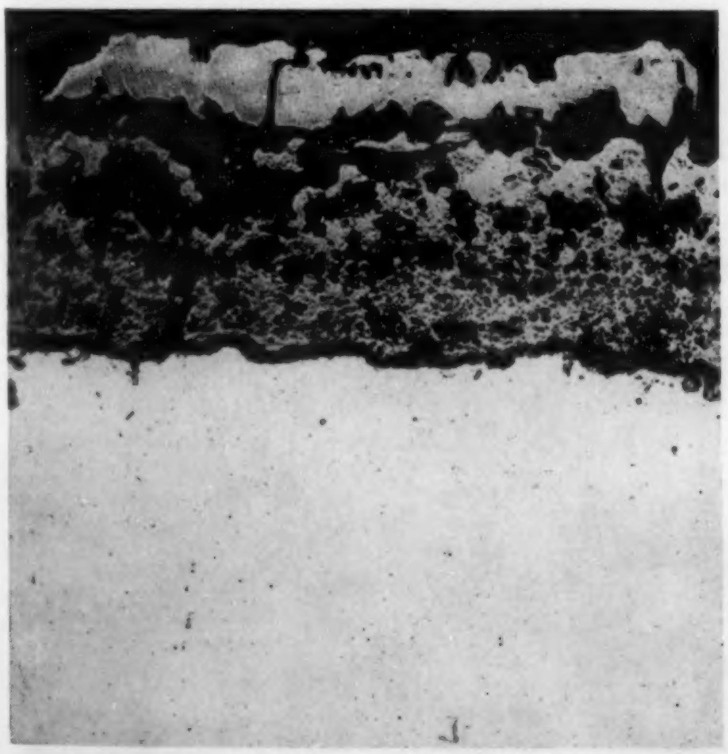
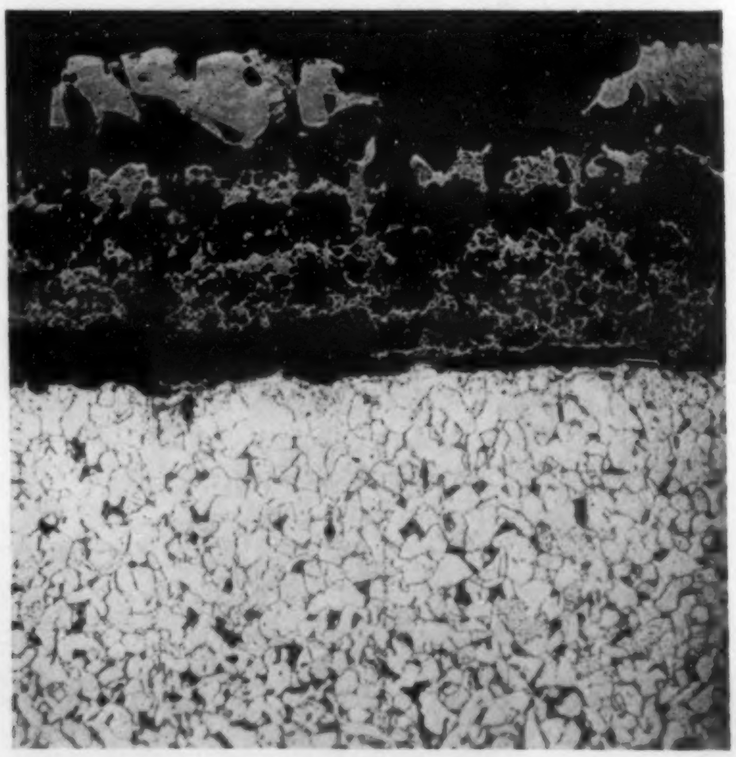
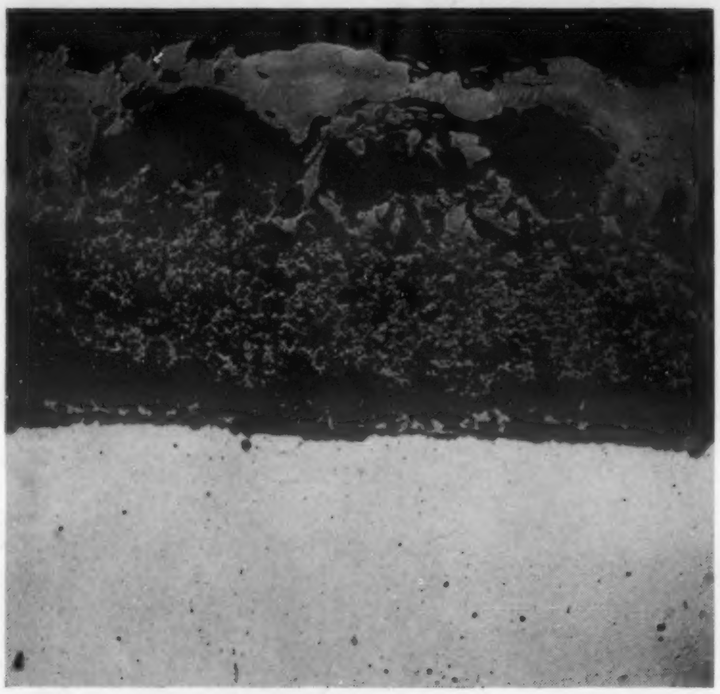


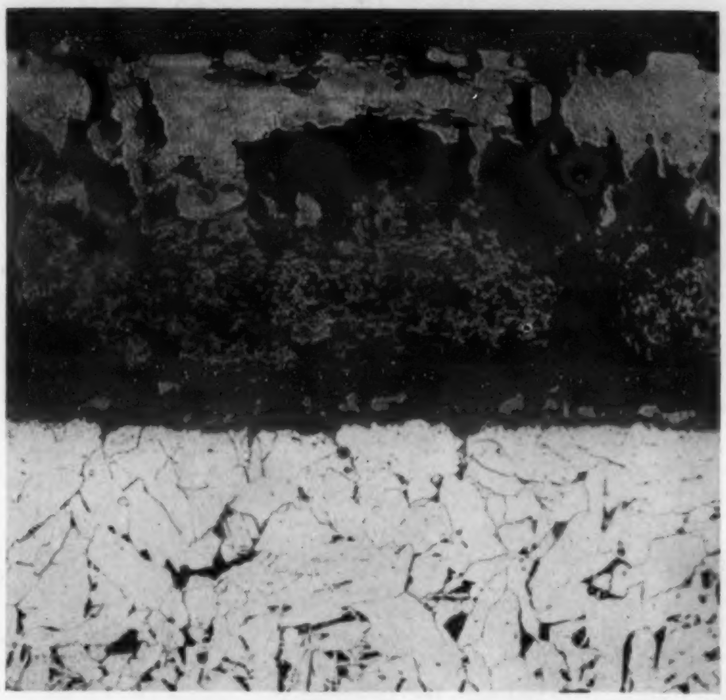
Fig. 15b. Cross section through the most highly stretched surface zone of the low copper forge test piece depicted in Fig. 9. Note smoothness of surface. Etched with nital. 50X.





Figs. 16a and 16b. Cross sections through surface of test cube of copper-bearing steel (0.26% Cu) soaked at 2,000 deg. F. for 1¼ hrs. Fig. 16a, unetched; Fig. 16b, etched with nital. Both 100 X.





Figs. 16c and 16d. Cross sections through surface of test cube of low copper steel soaked at 2,000 deg. F. for 1¼ hrs. Note relative smoothness of surface. Fig. 16c, unetched; Fig. 16d, etched with nital. Both 100X.

iron accompanied by the formation of a low-melting copper-rich phase under a layer of iron-oxide. This copper-rich phase may melt at a temperature as low as 2000 deg. F. and it then penetrates into the grain boundaries and weakens the cohesion between the surface grains. Any distortion of the grains by hot forming operations causes the grains to separate and surface tears or even serious surface fissuring ensues, particularly when the hot working temperature falls below about 1700 deg. F. It appears, therefore, that such copper-bearing steel should not be heated to above 1900 to 1950 deg. F.

In shop practice these requirements are difficult to meet, particularly with flame-fired furnaces, where accurate temperature control is difficult. The maintenance of a definite finishing forging temperature is also practically not feasible. This means, in other words, that in actual fabrication the steel will probably be heated up to 2000 deg. F. and also will be finished below 1700 deg. F. Under such conditions surface defects are to be expected with this copper-bearing steel.

It will be noted that the residual nickel happens to be very low, only 0.02 per cent, in the 0.26 per cent Cu steel. Reference to the data reported by Sullivan and Pavlish shows that of 20 cases reported where the residual copper ran 0.20 to 0.32 per cent, average 0.24 per cent, the accompanying nickel ran 0.04 to 0.10 per cent, average 0.07 per cent. The Cu:Ni ratio in the steel used was 13:1 whereas a more common ratio would be 4:1 corresponding to copper-nickel alloys of 7 and 20 per cent respectively. The latter has its solidus about 60 deg. F., and its liquidus about 200 deg. F. above the former. A tiny addition of nickel, if it were available for such use, might make a marked difference in the behavior.

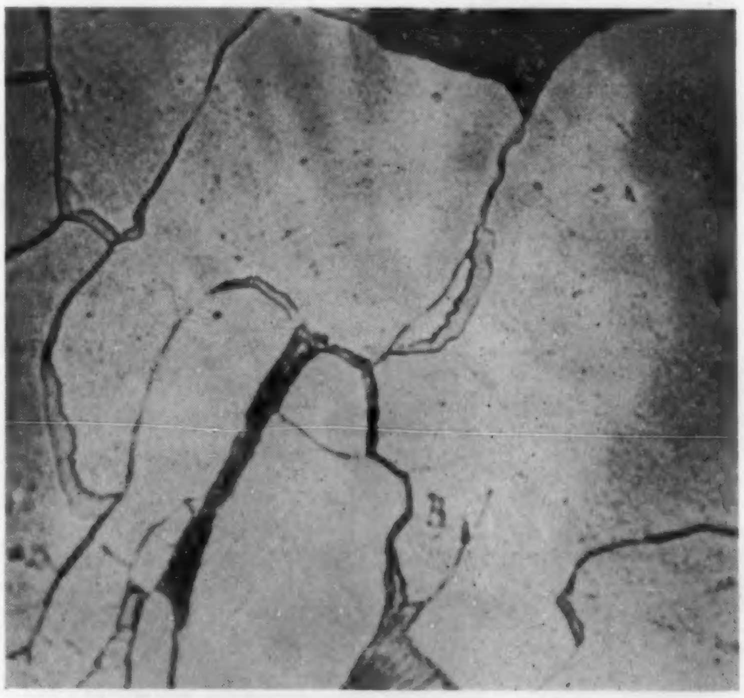
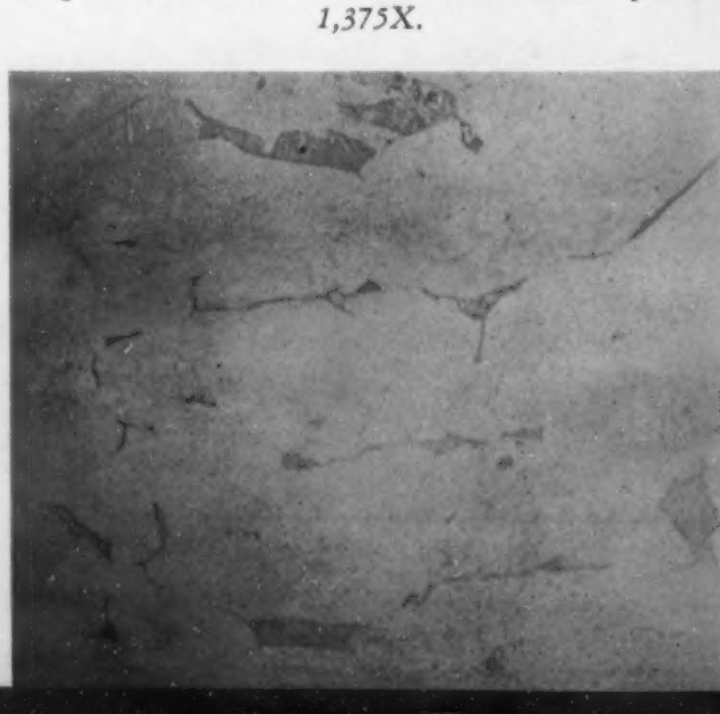


Fig. 17a. Microstructure of copper-bearing steel (0.26% Cu) showing carbide coalescence in the grain boundaries. Etched with nital. 1,375X.

Fig. 17b. Microstructure of copper-bearing steel (0.26% Cu) etched for carbides only. Note carbides in grain boundaries. Etched with sodium picrate. 1,375X.



Metallurgical Engineering
CONVERSION
to War Production

On the broadening shoulders of metallurgical engineers is still to fall, in the next few weeks, the heaviest weight of American industry's assignment to convert its plow shares into swords—to manufacture for the duration only those products that represent a direct and positive contribution to Victory. Although many plants have already completely or partly converted, or have taken the initial steps, a still greater number of shops have yet to face the problem squarely.

That it is an engineer's problem is becoming increasingly evident. Possible war products must be studied, materials investigated, processes examined and existing equipment surveyed as to its war-production utility "as is" or after modification. And when production starts, it is the engineer who must match quality with specifications, meet cost limitations, boost production and eliminate "bugs" both new and old.

But to either the engineer, business man or worker the phrase "Convert or Perish" is grimly and equally true. Our nation must convert to a war-time economy; our plants must convert to new processes, products or markets; individual machines must be converted by modification to do their new jobs. Without the necessary war materials for our Army and Navy *this year,* we as a nation may perish; without raw materials, now obtainable only for war production, individual businesses must perish.

This special conversion supplement is presented at this time to help engineers in the metal industries solve with dispatch the knotty problems of conversion — both in the preconversion and actual-operating phases — that now confront them. The supplement comprises three general divisions—an article outlining the broad aspects and detailing the specific phases of the conversion problem; a series of case histories of successful conversion, plus the story of one plant that is still looking for sub-contracts; and a very practical article on a technical problem that is giving many already-converted plants a lot of trouble. (There will be more of these how-to-do-it articles for plants now on war-production in subsequent issues.)

We gratefully acknowledge the cooperation and assistance received by us in this project from the personnel or publications of the War Department, WPB Contract Distribution Offices, the Office of Emergency Management's Photographic Division, the Research Institute of America and the various (and necessarily anonymous) metal-working shops that permitted us to describe their conversion experience.

—The Editors.

FROM PEACE TO WAR PRODUCTION

by Henry R. Clauser

Assistant Editor

The subject of conversion is a broad and complex one and to many plants, large and small, in the metal industries who wish to get into war production the picture is confused. Also, after talking with engineers, business men, WPB personnel, and various war agency procurement officials we became aware that there were many conflicting thoughts and opinions about conversion.

The purpose of this article is to clarify the conversion picture—point out and explain the various methods of switching to production for war, discuss the engineering aspects involved, enumerate the various ways of securing war contracts, and finally give pertinent suggestions on how to proceed in going after war work.

Total conversion from peace to war production is probably the most tremendous job that American industry has ever tackled. It means scrapping many of our set, peace-time ideas about design, use of materials, processing, fabricating, and applications of metals and forms in favor of methods that guarantee the most rapid and maximum production of war supplies. Where formerly time could be spent leisurely getting into production, that time must now be used in actual production. Where in normal times efficient operation is based on the principle of maximum production at minimum cost, now the most efficient business is that which can get up to maximum production and turn out the most war materials in the shortest possible time.

Production—fast, steady production—is the most urgent need right now, and all conversion efforts must proceed on that basis. A conversion that takes several years to complete may well be too late.

The purpose here is to give a detailed and comprehensive picture of conversion—the various degrees, types or methods of conversion; discuss briefly a number of the engineering aspects; and finally give definite suggestions and recommendations on how to get war work.

Types or Methods of Conversion

Conversion from peace to war production in its broadest sense means changing from the manufacture of goods for normal civilian consumption to the production of all the manifold materials which are needed to carry on total war. It does not necessarily mean the retooling of machines or the rebuilding of existing equipment. Although this is a most important method, it is only one degree or type of conversion.

There are other methods of converting to war production. In some cases it only means changing from peacetime methods of production, to a speeded-up war program. In other instances it may mean merely changing over to war-time markets, or by the use of existing facilities, produce war materials instead of civilian products. In such cases the use of different materials, new designs, and working to closer tolerances may be necessary. And in still another case it may mean the building and equipping of an entirely new plant.

Whatever the methods of conversion may be, there is only one purpose and one end: the utilizing of all possible resources for total war to defeat the Axis.

In exploring the various possibilities of conversion to war work that any one plant might have and what methods should be adopted, two controlling factors must be kept in mind—the time required and the materials needed for the change. Both these factors are vital right now. Below are listed the four chief types or methods of conversion. They are discussed in the order of their importance as to the time and materials required to get into war production. A plant bent on producing for war should examine the possibilities offered by these various methods in the same order.

I. Use existing plant facilities as they stand to produce essentially the same peace time product, but change from civilian markets to war agency customers such as the Army, Navy, Maritime Commission and Lend-Lease. In some cases, depending upon the product and its use, there is hardly any change in markets involved. For example, manufacturers of metal fabricating and treating equipment have automatically fallen into war production. Heat treating furnaces, machine tools, forging equipment are all needed for producing the implements of war and the only difference is the type products they are now being applied to. Here the only problem is expanding and increasing plant output.

However, there are numerous companies, large and small, that produced finished items in normal times which are needed by the armed forces. Some such items are: stoves, cooking utensils, construction supplies, instruments of all kinds, radio equipment, etc. In many such cases redesign of the product to meet specifications is necessary; often more careful production methods are needed to meet the close tolerance requirements; sometimes working in a different set of materials than before is specified and new production problems are created. (See "Case I," p. 768.)

It is obvious that this method of getting into production uses the least time and involves practically no new equipment. For these reasons a company should first investigate the markets created by the war and determine whether its regular product is still in sufficient demand to warrant continued production.

II. Use existing plant facilities, and with or without minor changes, produce a new product for military use. Some typical examples of this are a jewelry manufacturer who has been able to use his equipment to make electric meters for the Signal Corps; a company formerly making kitchen gadgets is now turning out screw machine components of small arms ammunition; a metal stamping plant with the same facilities has turned to producing a variety of new stamped parts for military needs. (See "Case II," p. 769.) Manufacturers of all kinds of machinery, such as printing presses, shoe, textile and wood working machines can change, with minor alterations, to producing the vitally needed machine tools and equipment for munitions production.

As in the first type of conversion, this method of switching to war production requires little time and material and should be used wherever feasible.

III. Revise, rebuild, alter existing equipment and facilities to produce a war-time product. This is perhaps the major method of conversion and the one most widely used. Often the job can be done by merely retooling the machines; sometimes it requires the complete rehabilitation of existing facilities, plus the addition of some new equipment.

Here both time and materials are needed to make the change. It is a large-scale undertaking and requires special skill and ability, preference ratings to get materials and new equipment, substantial financial support, and time which could best be spent in actual production. But for many plants this method of conversion is their only recourse. (See "Case III," p. 770.)

IV. Build a new plant or completely re-equip the existing one for producing essential war materials. In those cases where none of the existing facilities are adaptable to a war product it becomes necessary, if the company is to stay in business, to start from scratch and build what amounts to a new business. Such methods require a maximum of time and materials. An example of such a case is the manufacturer of metal housewares who completely re-equipped his shop and switched to making dies, jigs, fixtures and tools for the munitions industries. (See "Case IV," p. 772.)

Any break-down of conversion methods is at best arbitrary, for each individual plant is a special case. The above groupings are broad and general, but most cases fit into one of them. In some instances a particular plant may use several different methods. The points to remember are that there exist numerous possible ways of converting to war production and that the best conversion process is the one in which a minimum of time and new material is used.

Engineering Aspects of Conversion

The conversion job is primarily an engineer's job. The engineer must study and determine which of the methods or combination of methods discussed above is best suited to his conversion problem. To do this he must first make a comprehensive survey of the existing facilities of the plant. Then knowing what he has available, he must analyze his position and determine where his plant will best fit into the war program. Once settled on that point, he must plan the details of the change and supervise their execution.

The engineering aspects of conversion—that is, the factors which enter into the engineer's conversion calculations or the points which he must consider in his conversion programs are:

1. Materials
2. Time
3. Design
4. Equipment and facilities
5. Production methods.

Time and Materials: The importance of materials and time has been previously emphasized. Time is short and materials for construction, new equipment and auxiliaries are scarce. A major objective should be to produce the greatest possible volume with existing facilities.

Material substitutions should also be a consideration in any conversion program. In cases where the same product is being manufactured, but new, war markets have been developed, there are many opportunities for developing substitutes. A fine example of this is in the kitchen-ware field. To conserve nickel and chromium, some utensil companies that now sell to several war agencies, have succeeded in changing over to stainless-clad in place of straight stainless steel.

Design: Very often much can be done in matters of product design in converting for war production. Redesign and improvement of design are the chief considerations here.

In planning the conversion program for any particular plant, it is often possible by redesigning the peace-time product to fit it to military needs. Often this redesign only means changing from company blue-prints to government specifications. In many cases it means complete redesign of the product to fit a particular war agency's design.

Another very important design possibility is redesigning a product so that it can be fabricated with the existing plant equipment and facilities. At present there is an over-abundance of stamping, sheet-metal working, and casting (other than steel casting) fa-

Workers in a converted Pennsylvania plant assembling the elevating mechanism of a new 37-mm. anti-aircraft gun carriage. (OEM Photo)

cilities. Since this equipment does not lend itself readily to facility conversion, the only other possibility for such plants is to modify the design of some military products so that their particular fabricating methods can be employed. For example, forged products might be redesigned to utilize stamping presses; castings might replace products made with screw machines. Not only does redesign of this kind put plants which otherwise would be idle, into war production, but it also relieves some of the burden on other processing equipment, such as automatic screw machines, lathes, milling machines, forging equipment, etc.

Improvement of existing designs should always enter into the conversion survey. There are numerous instances where the design of products for military use are out-dated and where engineers, from long experience, can suggest improved designs to the military authorities. This practice is desirable and already some such suggestions have been accepted and have increased the quality of many items or have conserved the use of strategic materials.

Equipment and Facilities: In a majority of metal-producing and metal fabricating plants, the engineer finds it necessary to rebuild at least some of the existing equipment and facilities, and add some new equipment. The subject of converting equipment and facilities is much too large to discuss here. Each case is a story by itself with a different set of conditions and problems to solve. However, in every case, the time and material required to retool, alter or rebuild equipment are the important considerations.

Production Methods: Every plant doing war work or converting should be subjected to an engineer's appraisal of the production methods used. War production methods involve speeded-up, steady, efficient output of war materials. Often established production practices must be discarded and new techniques developed. Maximum production with a minimum of time should be the aim.

Following is a check-list of some of the things that the engineer should consider:

1. Is the equipment and production balanced and synchronized?

2. Are the equipment and operations properly arranged for the most efficient production?

From cooking utensils to airplane parts (and from 12 employees to 40) is the conversion story of the small Eastern factory in which this picture was taken. (OEM Photo)

3. Does the equipment receive adequate maintenance?

4. Are there possible changes in the specifications which would not lower the utility of the product, but would speed-up its production?

5. Could the design be simplified; could styles be standardized?

6. Could production methods be simplified?

7. Are the inspection rejects at a minimum?

8. Is waste material being salvaged?

There is really another aspect of conversion besides the five listed and discussed, but its relative importance is small. It is the factor of cost. Within reasonable bounds the cost of turning to work production and then of actually producing implements of war is a minor consideration. Only when the other factors are equal does cost enter heavily into the calculations. Speed of production is the primary aim.

How To Get War Work

In the previous parts of this article the methods or types of conversion and their engineering aspects were discussed. Now, here, are some suggestions and recommendations on how to get war contracts. It is no easy matter; the work will not come looking for you; you must go outside of your plant to get the business. Even after you have converted, you must still do a selling job.

There are two chief methods of utilizing your facilities for war work. One is on a prime contract basis and the other is through a sub-contracting arrangement. Prime contractors deal directly with the war procurement agencies which include the Army, Navy, Maritime Commission, Treasury and Lend-Lease agencies. Sub-contractors work chiefly with the WPB's Contract Distribution Offices or through direct contact of prime contractors.

If you feel that your facilities are such that they can qualify for a prime contract go to the nearest Procurement Planning Office of the Army, Navy, and Maritime Commission. Don't do this until you have on hand a complete list of facilities and equipment and have some notion as to what products you can probably make.

If you visit an Army Ordnance Procurement Office, for example, your case will be handled something like this:

(1) You will fill out a short, preliminary form in which you state your facilities, number of employees, type of product manufactured, etc.

(2) You will be shown through a display room in which are exhibited items that the Army is interested in buying.

A standard turret lathe is here shown being used for boring operations on 75-mm. pack howitzers at a large plant formerly manufacturing heavy electrical equipment.

(3) After this preliminary interview you will be asked to write a comprehensive letter or report to the Ordnance Department, expanding on the preliminary form you filled out. In it should be listed all facilities and equipment, financial status, business background, plant description, tolerances capable of working to, products manufactured, what war items could be produced, and all other pertinent data.

(4) The letter or report is placed before a board of expert engineers—each a specialist in certain specific war materials. Here it is decided whether your plant is feasible for war work, and if so what particular ordnance item it is most easily adaptable to.

(5) If your case is promising an Army engineer is sent into the plant to make a complete appraisal of your facilities with the view of making recommendations on how to get into war production. At the same time your company is thoroughly investigated as to financial status, reliability, business standing, etc.

(6) After all the above steps are completed the Army is ready to negotiate a contract and assist you with your conversion problems such as obtaining additional equipment, help on production methods and cost estimates, and getting sub-contractors.

The plants not suitable for prime contract work should contact their local Contract Distribution Office. Here you can file a list of your facilities and information about your plant equipment and production possibilities. The same can be done at the nearest war agency procurement offices. Although their chief interest is in prime contractors, nevertheless they are interested in knowing what subcontracting facilities are available. From these two sources a good idea can be obtained as to what kind of work prime contractors are farming-out, and just where your possibilities lie.

Attempts should also be made to solicit sub-contracts through direct contact of prime contractors who might be able to use your facilities. The Contract Distribution offices have information on prime contracts let, and will give you a list of prime contractors to contact. Through personal and business associates you may learn of others.

In going after sub-contracts you must convince the prime contractor of your ability to do the work by submitting full information about your facilities and business. Large war-products manufacturers are eagerly looking for good sub-contractors, but at the same time they must be extremely cautious in letting out work to smaller concerns. They have production schedules to meet and strict quality requirements to fulfill. A sub-contractor's failure to make scheduled deliveries might disrupt an entire production plan, or inferior workmanship might cause costly rejections in the finished product.

There are two other possibilities of getting into war work which really combine prime and sub-contracting. The one method, known as the "mother hen" plan offers an opportunity for firms which have strong managerial and technical staffs, but do not have the required facilities for producing war items. With such a set-up it is possible to enlist the aid of small plants having suitable equipment, then go after war contracts as a prime contractor, farm out much of the work to the smaller units, assist them by giving financial and management aid, engineering assistance, and perhaps do an assembly job.

The other method of securing work to aid in the war program is to participate in a war production pool. The plan essentially consists of a group of small manufacturers joining their facilities and operating as a single plant. In this manner the association can qualify for a prime contract.

To pursue such a plan it is first necessary to survey and list the production facilities of the "pool" members, contact the Contract Distribution Office and proceed to comply with the various conditions entailed in keeping clear of anti-trust violations. Then secure the services of competent engineers to study the facilities, determine what war products can be made, and handle the necessary conversion problems as well as the subsequent production.

Getting into war production is not an easy job. It requires all the managerial and engineering skill you have at your command; it requires patience and persistence; it requires careful, definite planning. The job should be approached in the same efficient manner with which you meet your regular production problems.

The conversion task is primarily yours. The Army, Navy and War Production Board will cooperate and give you all the assistance they can, but it is your own desire to convert, your ability and ingenuity that must in the final analysis do the job of producing for war.

SOME TYPICAL CONVERSION CASE HISTORIES

The task of converting a given plant, while formidable, can still be approached through several avenues. From among the various possible methods of placing his plant on a basis of complete participation in the war effort, the engineer must select that one which can be adapted most closely to his particular shop's facilities, "know-how" and markets.

In the first article of this supplement, four general forms of conversion to war production were outlined—(1) changing to a war-time market; (2) a process-design change utilizing idle facilities; (3) modification of existing manufacturing equipment; and (4) a complete change to a new business. Now we present 4 typical case histories of plants that have already converted and are now on full production of materials and equipment for the Services—each case illustrating specifically one of the foregoing "formulas" for conversion. —*The Editors.*

KITCHEN UTENSILS FOR THE SERVICES

Case I—Changing to a Wartime Market

There are many instances where companies have continued making the same kind of product they were familiar with during peace time but have found new applications for their products and have turned them into war time markets such as the Army, Navy, and Maritime Commission. A fine example of this type of conversion is given by a kitchen utensil manufacturer, who has continued making pots, pans, tableware, and sanitary items but has steadily developed the government as a customer in place of civilian markets. By doing this he is aiding the war effort by supplying the armed forces with cooking implements, and sanitary ware, and at the same time he is able to continue in his business which otherwise would have to shut down for lack of materials.

In converting their products over to the war-time markets, they were required to make the utensils according to the set specifications of the Army, Navy and Maritime Commission. Through 45 years experience in the business, they saw a number of improvements which could be made to the various existing designs and materials specified by the war agencies. These they presented and succeeded in getting a number of them adopted.

One of the most important alterations which the company has urged and which it has been partially successful in having adopted was the substitution of single clad stainless steel in place of straight stainless steel. It was obvious that such a change would contribute greatly towards conserving such scarce and critical metals as chromium and nickel. The company had been experimenting for over a year on the deep drawing of single-clad stainless steel and they believe that they are among the first to solve successfully the many difficulties involved. By continuous effort they were able to work out proper annealing and deep drawing methods which were applicable to drawing utensils as deep as 22 inches without cracking or losing the corrosion resistant properties of the stainless cladding. In arc or resistance welding the handles and other accessory items to the utensil bodies difficulty was first encountered in burning through the cladding, but this problem, too, was solved.

Back in September, the company received their first order from the Army Medical Corps for stainless-clad cooking utensils. At first the specifications required a double clad stainless to be used. However, as nickel and chromium mounted on the scarce materials list, the specifications were changed to the use of only a single-clad, with the stainless on the inside surfaces of the utensils which come in contact with the food. Later the company sold the Navy on the idea of using stainless-clad steel instead of straight stainless, to the extent of specifying this material for galley tubs.

But now, various conservation agencies are advocating the elimination of all types of stainless steel entirely and its replacement with straight carbon steel or enamelware. This utensil company foresees the impracticability of such a change. Cooking pots of plain carbon steel without any protective coating would rust rapidly and become useless in a short while. Enamelware is impractical for the rough, hard service it would receive in the field kitchens and ship galleys. Chipping of the enamel would occur and expose the steel under the surface to corrosive action. Besides this some foods may not be cooked in enameled utensils because of the chemical action occurring between the food and enamel. Finally, the enamel specified by the Navy is composed, among other things, of scarce tin, cobalt and antimony.

In an attempt to solve the problem of conserving the chromium and nickel and at the same time produce a satisfactory cooking utensil, they have successfully experimented with silver-clad steel. This material they hope will be used as a substitute for the stainless-clad steel. Although more expensive, it is readily workable, and resistant to corrosion. Silver is available and could be reclaimed after the war.

Another instance where they have suggested design changes is in the sink bowls installed on war-ships, particularly on the "mosquito" boats. Sheet copper, nickel or chromium plated, has been used for this item. Generally the bowls have been hand formed with the seams welded. On the smaller boats the constant vibration has caused the welded seams, in many cases, to crack and fail. With their knowledge of working stainless steel they have been able to produce a deep drawn stainless steel bowl, thus eliminating the welded seams and possibil-

ity of leaking. The seamless drawn bowl is also much lighter than the hand-made article.

And still another case of design and material change was made in cooperation with the Maritime Commission. This utensil company suggested that stainless tableware (containing 8 per cent Ni) be substituted for the silver-plated "nickel silver" (containing up to 26% Ni) designs. The suggestion was accepted and has resulted in substantial savings of nickel.

Besides these, numerous other minor changes were effected in the design of various small parts of cooking utensils such as pot handles and spouts, as well as in the shape, thickness of material, etc. All of them indicate the alertness of this small company and its eagerness to help the war effort.

REDESIGNING FOR STAMPINGS AND CASTINGS

Case II—A Process-Design Change That Utilizes Idle Facilities

by W. F. Burchfield

The International Nickel Company, Inc.

It is possible in many instances to put facilities of plants which are below capacity into war production by modifying fabricating methods. For example, at present there is a surplus of stamping plants, sheet metal fabricators, and foundries (other than those producing steel castings) whose production in normal times covers a range of products from jewelry items to automobile bodies and household utensils. By the proper conversion of design and materials, many of these idle facilities can aid the war effort in a variety of ways.

Already there have been many successful attempts along these lines. Many stamping plants, for instance, since they have been accustomed to the handling of specialties, have been useful in the rapid production of vital parts for heavy pieces of equipment. One large company with wide facilities for the stamping of many different kinds of equipment is now working on ordnance items. Some of these stamped items are replacing forgings and are releasing machining and forging capacities badly needed for purposes for which substitute facilities are not suited.

Another company now is being called upon to provide stamped alloy steel motor parts. This type of construction can provide a strength and lightness in weight not possible in the heavier castings previously used. The stampings also can speed deliveries and lift a burden on steel foundries. This company's designing engineers have studied materials as well. In one case it developed a piece of equipment in steel that, by change of design, was used to replace a part formerly made of aluminum and, at the same time, achieve a decrease in weight. This of course, did not involve a discussion of the relative merits of the two metals so much as it did the position of aluminum on today's critical list of materials.

There is another case in point which furnishes a striking example of the ability to shift from peace to war production. It is that of Goat Metal Stampings, Inc., Brooklyn, N. Y., whose personnel have been trained and whose plant is equipped for the stamping and other high speed forming of specialty metals—such as Monel, nickel, and a variety of nickel alloys.

Among the war items to whose production the Goat facilities were found especially adaptable was a Monel part for a piece of Naval ordnance. Machining of this part out of bar stock originally had been considered by the primary contractor. Such operations, even on automatic machines, are obviously slower than deep drawing or stamping. Furthermore, up to 70 per cent of the original stock can be lost as small scrap in machining. While much of this scrap can later be salvaged, it requires careful segregation and cleaning before it can be sent to the re-melt furnaces. Above all, it ties up badly needed material. Instead of bar stock, the Goat Company used light blanks stamped from Monel strip. This cut down the amount of material required and also reduced to a minimum the need for machine tool work, since the blanks could be formed

These stamped, deep-drawn or coined parts require little machining and thus release machine tools and forging equipment for other work.

to close tolerances.

Another job handled by the Goat Company was the forming of two important airplane parts from a rust-resisting nickel alloy. Here again the press was able to relieve the machine tool of most of the work involved. And it did it speedily and satisfactorily.

From a large producer of airplane engines, the same company received an order for magneto brush segments. These are blanked, coined, and drilled from pure nickel strip on standard presses used in normal peacetime operations at the plant. Previously they were machined and drilled from solid metal.

Many foundries—aside from those producing steel castings—have capacity in excess of their present production. While for heavy duty ordnance purposes specifications almost uniformly call for forgings, engineers have been able to modify and alter designs so that a range of mechanical properties often can be attained that will be more than sufficient for a large number of items. Non-ferrous foundries, while busy, still have capacity that can be used to relieve burdens elsewhere.

Much has been accomplished by industry as well as government agencies in spreading out the load of war effort—a spreading out that not only results in breaking bottle-necks, but also in keeping plants operating which might otherwise be closed by shortage of raw materials.

ADAPTING FACILITIES TO PRODUCE BOMB FUZES

Case III—Modification of Existing Manufacturing Equipment

In getting into the production of a great many war items, such as small arms and munitions of all kinds, automatic screw-machines are probably the most important single facility to have. Also vitally essential are the various other machine-tools—lathes, milling, drilling and finishing machines.

Not only is it important to have these tools, but it is also necessary that they be capable of being used for close tolerance work. Most of the manifold small parts going into various munitions require precision work, since the mechanisms which they make up are delicate and require close, sure fits. For example, fine tolerance work on the order of .001 in. is mandatory in the manufacture of bomb nose fuzes. This mechanism is made up of many, small component parts, which for proper assembly and positive, accurate operation, must necessarily be worked to exact dimensions.

To many plants which formerly produced peace time products not requiring close tolerances, the precision work necessary in munitions manufacture was unknown; if they are to convert successfully to war production, their machines must be adapted to close precision work. In a great many instances the available machines are not convertible for working to close tolerances. In such cases the machines might be used for the first rough cuts, and new or rebuilt equipment obtained for the final or finishing operations. One ingenious machinery manufacturer, who lacked the necessary equipment for close tolerance work, bought up a number of ancient lathes—30 to 40 years old—rebuilt them in his own shop into single purpose lathes which did the precision work required.

As was mentioned before, to get into the production of a majority of ordnance products, the plant must have available a substantial inventory of machine tools such as screw machines,

Facilities List for the Production of Bomb Nose Fuzes

Representative Machine Tools Uses

Tumbling Barrels	Milling Machines
Spring Coilers	Cadmium Plating Equipment
Electric Furnaces (small)	Arbor Presses
Turret Lathes ½" to 2¼"	Punch Presses
Auto. Screw Machines 5/16" to 2⅝"	Balance Scales
Cut-off Machines	Thread Milling Machines
Drilling Machines	Gear Hobbing Machines
Multi Spindle	Gear Shaping Machines
Finishing Machines	

Types of Tools, Fixtures, Jigs and Gages Used

Cams	Assembling Fixtures
Counter Bores	Bending Fixtures
Milling Cutters	Milling Fixtures
Drills	Riveting Fixtures
Reamers	Staking Fixtures
Formed Cutting Tools	Soldering Fixtures
Punches & Dies	Drill Jigs
Snap Gages	Thread Gages
Ring Gages	Plug Gages
Flush Pin Gages	Profile Gages

Representative Number of Gages Used

About 700 gages have been used involving about 125 different gaging operations

Tolerances

Range from ±.001 to ±.010

Estimated Production

Approximately 3300 direct machine hours are required for the production of 1000 fuzes. This includes an allowance for maintenance and set up time. No allowance has been made for overhead and tooling up. This estimate includes all gears which were procured commercially.

lathes, milling machines, etc. Upon the basis of such machinery, the ordnance engineers can aid in planning the additional facilities required to get into production. Following are two typical cases where some, but not all, of the tools for munitions production were available, and with the aid of Army ordnance engineers, the needed facilities were planned. Then it was chiefly the job of the companies themselves to find means of securing the additional equipment.

The one company made zipper fasteners in peace-time; the other manufactured a variety of products, including vacuum cleaners, electric blowers, exhaust units, electric floor polishers and can openers. Both organizations were anxious to use their facilities for war production. After surveys were conducted by the Army ordnance engineers in cooperation with the company engineers, it was found that the facilities and equipment would be best adapted to the manufacture of bomb fuzes.

The accompanying table gives the equipment and facility list for the manufacture of bomb nose fuzes. A study of the table clearly shows the complex nature of just one ordnance item and the variety of equipment required for its production.

To turn their efforts to the production of bomb fuzes, these two plants had to alter a lot of their existing equipment and then complete the conversion job by building their own equipment, sub-contracting wherever possible, and installing new equipment only where it was absolutely impossible to find sub-contractors.

In the case of the zipper company a general survey showed them to have the approximate facilities as follows:

Drill presses
Grinders
Shapers
Engine Lathes
Punch presses
Hand screw machines
Welding equipment
Heat treating equipment
Special machines

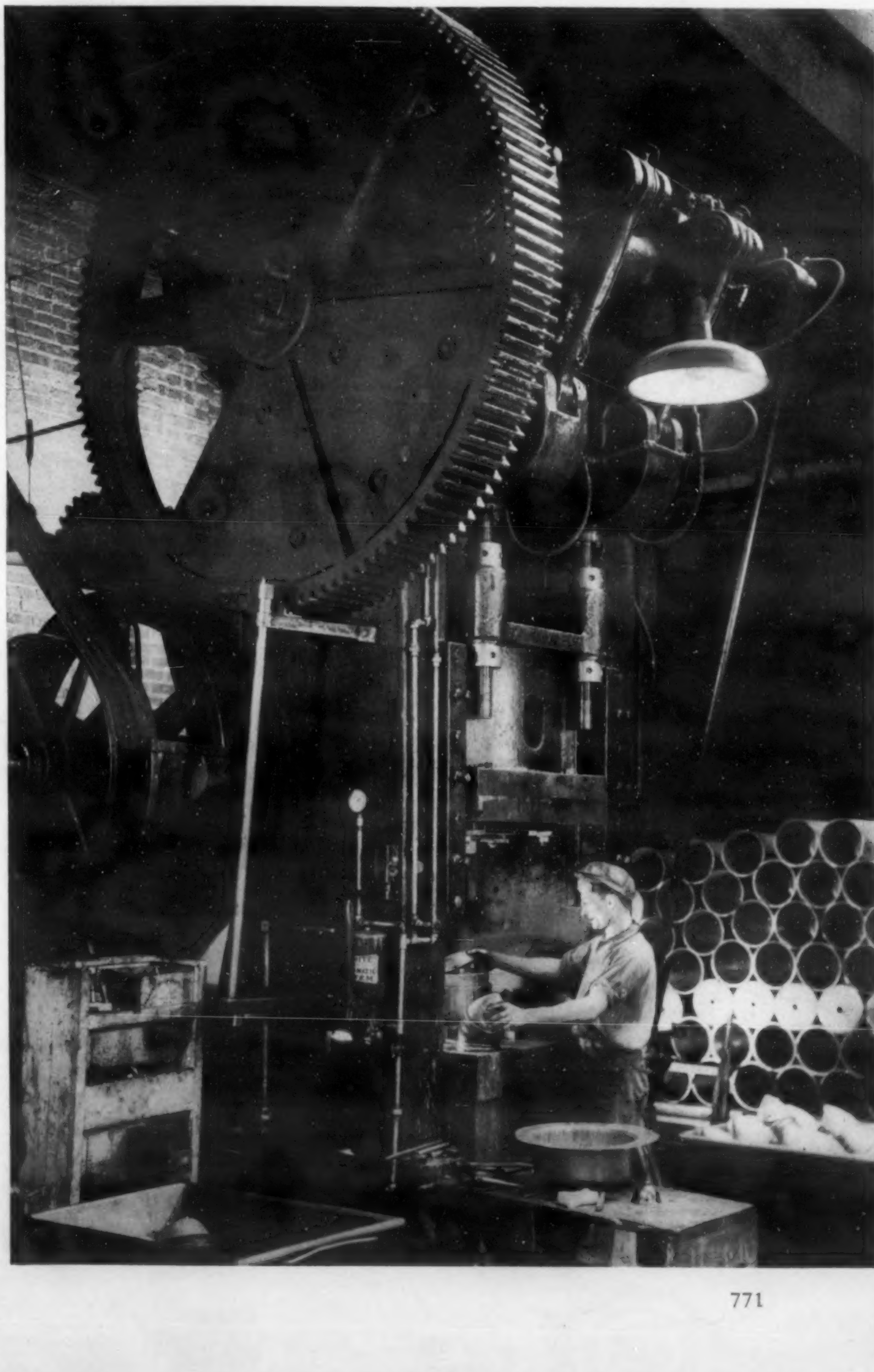
The vacuum cleaner company had a similar list of equipment upon which the conversion to the manufacture of bomb fuses could be based. Their facilities included:

Hand screw machines
Automatic screw machines
Milling machines
Lathes
Grinders
Buffers
Power punch presses
Drill presses
Foot presses
Arbor presses
Riveting machines
Plating equipment
Paint spray equipment
Miscellaneous and special tools

Much of the existing equipment in the two plants needed alterations and some of the machines were not at all adaptable to the war product. In many instances entirely different tools, jigs, fixtures and gages were required.

To make up the shortages in the equipment necessary to get into production, every possible attempt was made to sub-let work to companies who already had facilities to produce certain parts of the bomb fuze. Some

Deep cold-drawing of Monel for fabrication into shells, cylinders and other shapes in assorted gages for various war products, as described on page 769.



of the additional equipment required was built by the companies themselves. At the time the conversion took place in the zipper plant, turret lathes were not available, so the company built them from the ground up in their own shops. Where all other attempts to use existing facilities failed, the companies were authorized to obtain new equipment.

These two cases of conversion took place a number of months ago. Since then, machine tools have become even more scarce and hard to get. This critical condition requires that continued emphasis be placed on the fact that the most desirable conversions are those in which existing facilities are adapted to war production and a minimum amount of new equipment has to be purchased and used.

FROM METAL HOUSEWARES TO ORDNANCE TOOLS

Case IV—A Complete Change to a New Business

A unique conversion case is that of a company formerly manufacturing metal housewares, which now has changed over 100 per cent to production of tools and dies for munitions industries. Its peacetime products were housewares and house-furnishings made of various soft metals and alloys including aluminum, copper alloys and pewter.

The dies to form these metals were made in their own small shop. The die-making department was only an auxiliary or aid to the production plant during normal times. Now, in war, the company has dropped completely its peace-time production items, converted all possible equipment, and with the addition of new equipment has become exclusively a die, tool, and fixture producing establishment for the duration. Tools, dies, fixtures, forcers, etc. are now this company's end products, in place of housewares and furnishings.

In the manufacture of their peacetime products few close tolerances were required and only soft metals were being worked, so a minimum of technical and engineering problems were encountered. Besides this, time was not at a premium and their die and tool work could be handled in a more or less leisurely fashion on a piece by piece basis. Experimenting and altering machines and dies was possible.

Because the company's business was the manufacture of metal housewares, a major part of the plant's facilities included presses, stamping, spinning and finishing equipment, while only a minor proportion of the machines were suitable for tool and die making. In the conversion process it was therefore necessary to rebuild as much of the equipment as possible for precision tool and die making work and replace the unconvertible facilities with suitable machinery—lathes, drill presses, milling machines, grinders, etc.

But the conversion process went much further than this. Dies, and tools and fixtures used in the manufacture of munitions require close tolerance work. At the same time these products were needed in large quantities and in a hurry. So all existing suitable machines were carefully checked for their ability to do exact dimensional work, and then this equipment plus the new machines arranged and utilized for the maximum and fastest possible output.

Perhaps the most interesting points about this conversion are the technical aspects of the switch from the production of dies for use on soft metals to dies designed to work on steel. Previously, relatively soft die materials were used such as zinc alloys and other non-ferrous metals. For many jobs soft, non-ferrous metals with a steel backing were employed.

In the production of their normal product few technical problems were involved. Most of the work of making the dies for housewares was carried on by rule-of-thumb methods and not a great deal of attention was given to obtaining the optimum properties in the various die materials used. Since soft metals, such as aluminum, copper, lead alloys, and pewter, were being worked, the die did not have to possess very great hardness or toughness. The only heat treating operation normally involved was the annealing of the die stock so that it could be worked and formed easily.

Now, most of their work calls for hard, tough dies to work steel for munitions parts. Such work requires dies made of steel ranging from the high carbon and low alloy steels up to the highest-hardness tool-quality steels. The introduction of these harder die materials to their shop required an extensive enlargement of the heat treating equipment. Formerly they had only to anneal the dies; but now in using die steel, it is necessary to first anneal the stock for machining and then heat treat it to obtain the desirable hardness and toughness properties. This generally requires a quenching and drawing operation which heretofore was seldom performed in this shop.

To take care of the new heat treating requirements, a complete, modern heat-treating department was set up. To begin with, the company owned one small muffle-type furnace which could handle only one die at a time. Now their facilities include gas-fired and electric furnaces—all controlled atmospheres—cyanide pot furnace, and complete quenching equipment. One of the furnaces has 20 times the capacity of the small furnace with which they originally started.

The actual shaping and finishing of the present dies is not as simple as it used to be for their normal product. Metal housewares usually require flat dies, only roughly finished. High grade lapping is not necessary. Bullet dies, for example, in contrast require a round die highly finished and, to come up to Ordnance Department specifications, no surface marks or scratches of any kind are permitted.

The introduction of close tolerance work and the necessity to meet strict government specifications made it necessary to organize an inspection department. The department now consists of five men who work in cooperation with the prime contractor and army inspectors and pass on all work done in the shop.

WANTED: SUBCONTRACTS!

by Fred P. Peters

Managing Editor

The preceding pages of this "Conversion" supplement have outlined the general and procedural aspects of converting to war production, and have offered some pointers for manufacturers seeking subcontracts. Now we present the story of a metallurgical engineering shop that has tried persistently to convert a major part of its facilities, but without success, even though there are many jobs it could readily handle with much benefit to the general war effort. Many other plants may be in the same unfortunate situation, and it is to aid in ameliorating this condition that we direct attention to it in this article. We shall be glad to send the name of the company described to anyone who asks.

Mr. S. is extremely patriotic. His company for over two generations has successfully operated a growing business, making precious metals in various semi-finished forms and fabricating precision products for the dental, optical, jewelry, watchmaking, electrical and other industries. His business is booming; unlike most small companies, he doesn't *have* to convert (for some time, at least), since his raw materials are chiefly gold and silver, of which no serious shortage is in sight.

But Mr. S. *wants* to convert, and has wanted to for many months. He believes that to win the war not only every pound of militarily useful raw material but *every machine adaptable to war production* as well must immediately and henceforth be used in the war effort. And he feels more than vaguely disturbed about his rolling mills, power presses and brazing furnaces busily producing dental inserts, spectacle wire and jewelry stock when they ought to be making fuze parts, aircraft precision products or rolled metal in special lots for the brass industry, for example.

But, although he has aggressively and intelligently sought war production jobs, his shop is still less than 10 per cent converted.

The Company's Facilities

In general, the "S" company is equipped to perform all the operations required to produce metal sheet, strip and wire and to fabricate a variety of formed, pressed, machined and assembled precision parts therefrom.

Some of the fabricated parts this company regularly manufactures are shown below. Parts can be produced ordinarily to better-than-commercial tolerances—among the present products, for example, are precious-metal washers with an O.D. of 0.050 in., I.D. of 0.036 in., thickness of 0.012 in., and tolerance in all dimensions of $\pm.0005$ in. Some of the company's regularly-manufactured products include laminated sheet and wire (silver-on-steel, silver-on-brass, gold-on-silver, brass-on-steel), silver-on-steel bus bars, silver rivets, composite rivets, electrical contacts, precious metal dental attachments, backings, solders, lingual bars, etc.

The plant also has good tool room facilities able to produce (or maintain) a limited volume of small tools and dies and to perform simple machining operations such as milling, planing and shaping. The entire plant covers about 23,000 sq. ft. of floor area, and employs about 100 people.

Specifically, these facilities include (1) seven melting furnaces capable of handling charges from 1 to 150 lbs.—now used for melting gold, silver and other non-ferrous alloys.

(2) Eleven rolling mills able to take ingots up to $1\frac{1}{2}$ in. thick and roll to 1/16 in. thick in 6-in. wide stock, or to very thin gages in stock less than 4 in. wide, and 4 small wire-rolling mills.

(3) Five hydrogen atmosphere annealing, brazing and soldering furnaces.

(4) One large drawing press, 7 smaller power presses and 18 foot presses.

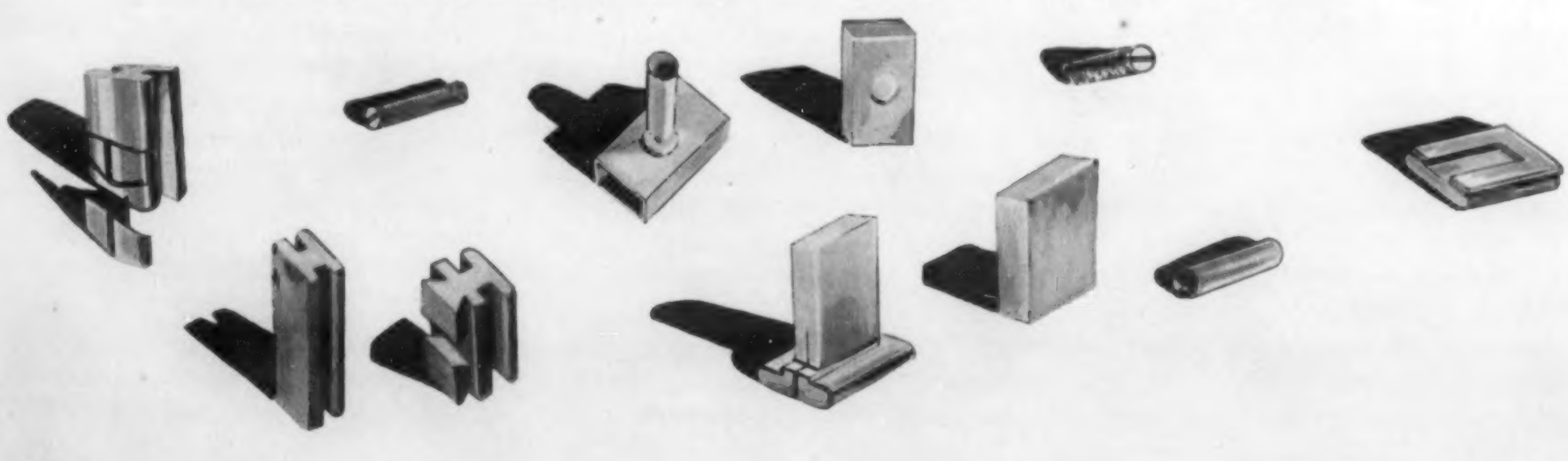
(5) Five cold-heading machines.

(6) Several slitters.

(7) Two rotary swaging machines.

(8) Three spot welders (one 10-kva and two $1\frac{1}{2}$-kva machines).

Some of the small parts regularly manufactured by the "S" company, mostly of noble metals or bimetallic combinations. Parts shown are about 3 times their actual size.



(9) Four bench lathes, and good bench assembly equipment.

(10) Tool room facilities as outlined in an earlier paragraph.

(11) Unusual ingenuity with processes and operations in the persons of the plant supervisors and certain "craftsmen" in the shop.

On most of this equipment work can be produced to better than commercial tolerances. The outstanding features of the plant's present facilities are their overall flexibility and their evident applicability to a variety of special jobs of a small-lot nature. The availability of a metallurgical and physical testing laboratory should also be mentioned.


Pouring a silver melt.

Utilization on War Work

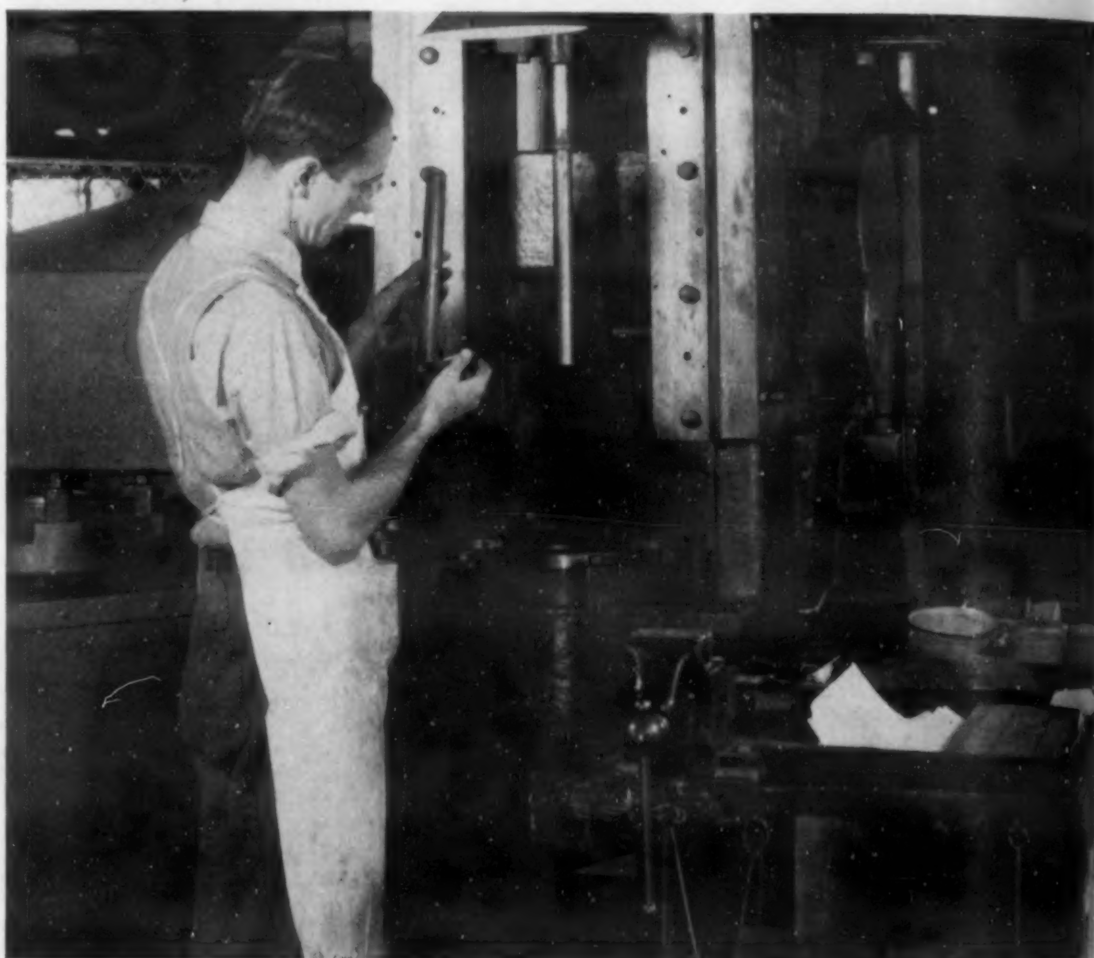
Several months ago Mr. S. made a personal appraisal of his shop's capabilities from the war production viewpoint. He could, of course, continue to supply gold, silver and platinum stock for the non-essential jewelry market, which continues to clamor for his products, or he could aggressively promote precious metal products as substitutes for highly critical copper, nickel and chromium alloys or platings in "civilian" production. But he favored neither of these if he could find some way to contribute substantially and directly to the manufacture of munitions or war-production machines.

In general, he appraised his possible major war-production functions—in addition to continuing the manufacture of such essential items as electrical contacts for Army and Navy communication equipment—as threefold:

(1) Producing small pressed, formed or machined parts to close tolerances.

(2) Providing a limited tool and die service, where rather broad tolerances are involved.

(3) Processing (re-rolling or re-drawing) small batches of special-sized or special shapes of bar, rod, wire, or strip stock in copper, brass, nickel alloy or aluminum, for example, to relieve the big high-production non-ferrous mills of the "nuisance" of setting-up and producing such material themselves.

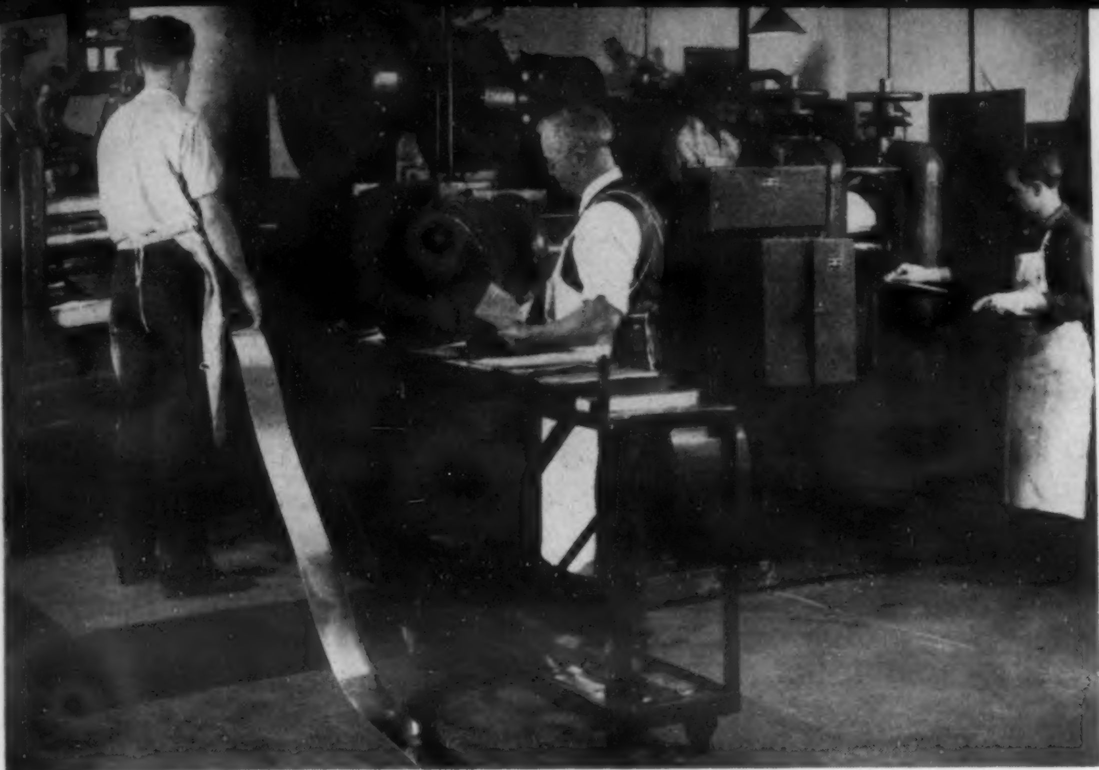

Drawing cylindrical parts on the "S" company's large drawing press.

After six months of canvassing, corresponding, visiting, inspecting, estimating, bidding and arguing, Mr. S.'s total "war orders" comprise (1) a glamorous but unsubstantial assignment to draw very fine gold-on-silver wire for the gold braid on officer's uniforms; (2) a sub-contract from a large electrical manufacturer to machine, drill and assemble certain switchboard components, requiring the labor of about 2 men a day; (3) a couple of milling-cutter jobs for the tool-room, good for a week at the most; and (4) two or three "trial orders" from two large non-ferrous metal consumers, involving small lots of special sizes and shapes; although these were very promptly filled and were well within specified tolerances, there have been no repeat orders.

For the gold braid and switchboard jobs Mr. S. is grateful. They are a satisfactory beginning. But he is distressed by what he calls an inability on his part to find the spots where his company can be of service.

The Search for Subcontracts

For three solid months Mr. S. turned a capable and intelligent young man loose in the field, had him call on all the large Eastern plants that would



Rolling precious metal strip.

Some of the machine-shop facilities of the "S" company.

almost certainly be in need of supplementary facilities and innumerable others that might have precision or tool jobs on which his company could help. He visited Army, Navy and WPB offices in many cities.

Back to Mr. S. came a steady flow of inquiries, blueprints, forms and requests for estimates. Eagerly and at length they were studied, estimates prepared and bids entered. But in virtually every case—*even when he knew his bid was the lowest*—the contract or subcontract went to a larger company. The explanations usually given were that the successful bidder was already making the item and was therefore more dependable.

Very often his bid was too high for consideration, the larger plants naturally being able to distribute their overhead charges in such a way as to arrive at a much lower cost per job than he could meet. In other instances, he is certain that actual manufacturing experience with the job would show either that his original bid was erroneously figured too high or might reveal manufacturing short cuts that would permit lower costs.

Some Specific Suggestions

It is entirely possible that much of Mr. S.'s trouble is due to the inability of his machines to manufacture to the microscopic tolerances specified for many war-product components, or (as mentioned above) to the somewhat higher operating costs for certain jobs when run on his machines as compared to the operating costs on the equipment in larger plants. But even with these instances discounted, there still remains a relatively large sphere of war-production operations in which Mr. S. could render substantial service, and in specific ways for which his shop already has demonstrated its suitability.

It is impossible to believe that Mr. S.'s situation typifies that of the small manufacturer who has sought sub-contracts. On the other hand, we can be sure that his case is far from unique. And even a few shops like his, carelessly left out of the war effort, represent a major hole in our program for the greatest possible production in the shortest possible time.

Neither we nor Mr. S. can specify the exact method of remedying the situation. Perhaps the large mills that cannot process material in short order should be required to sublet the job to any shop that offers its facilities and that can demonstrate its ability to handle the work. Or maybe the services or contractors should be required to note what part of each bidding plant's capacity is unoccupied with war work at any moment, and to avoid giving orders to fully-loaded plants when there are among the bidders shops with immediately-available facilities.

A necessary adjunct to this last type of order-placing would be the use of a job-pricing system whereby the Army, for example, would indicate that it was in the market for so many hundreds of an item for delivery before a specific date and *at a stated price of so much* per unit. The order might then be distributed among the interested and competent plants according to their present "room" for such orders.

But whatever is done should be done quickly. We can't control the decisive turn in the war during its crisis—*this year*—if needed matériel **is jammed-up in some plants while others able to produce it at once go vainly begging for the orders!**

Practical Pointers on Operating Problems

Not all the problems of conversion to war production are connected with planning and preparation for the switchover. In many instances there seems to be an even greater need for operating information of the how-to-do-it type by plants after they have re-organized, re-tooled and actually commenced making the war product. Many shops have courageously undertaken war-production assignments involving materials, practices and processes with which they are completely unfamiliar and upon which even engineers experienced in such work look with respectful awe.

Certain of these technical production "bugs" are apparently common to a surprisingly large number of newly-converted metal-working shops (and to not a few of the early-converters, too). In the series of articles of which this is the first, we will ferret out those technical war-production problems that are most broadly annoying and present some practical pointers on the right way to do each job so as to avoid the usual troubles.

Two such widely-encountered problems and recommended operating practices for solving or obviating them are presented in this article. The operations described—hardening cartridge-case dies and punches—are the day-by-day concern of scores of plants. Other analogous problems, involving materials, machining, forming, forging, welding, heat treating, finishing, inspection, etc., will be similarly treated in subsequent issues of METALS AND ALLOYS. Watch for them!

—The Editors.

HARDENING OF CARTRIDGE DIES AND PUNCHES

By R. B. Seger

Plant Superintendent, Lindberg Steel Treating Co., Chicago

One of the most generally-occurring production problems introduced by the Victory program is the hardening of cartridge dies and punches. The number of such hardened tools required per day to maintain cartridge case output at projected levels is astronomical, and the heat treating work, now distributed among many shops, is causing a lot of headaches. The following pointers are offered to assist some of the "newer" and possibly less-experienced war manufacturers over certain common heat treating difficulties.

Dies

To many it is hard to understand why only the hole of the dies is hardened. In actual production, these dies get a tremendous amount of punishment and if hardened all over, they are very likely to burst open. By hardening only the hole, the die can be left full hard on the working surfaces and still have a very tough shell on the outside diameter, thereby eliminating the bursting in production.

There are many methods employed to accomplish this during quenching. The two most familiar are playing a stream of water, held manually, through the hole, and the use of asbestos-covered steel rings that seat into the ends of the dies to keep the quench confined.

Some of these methods work properly and some are worse than hardening all over. The important part of quenching is to keep the quench flowing only through the hole. The worst possible condition is to have partial leakage, thereby hardening only very small portions of the outside diameter. A condition such as this will cause the die to crack in hardening or give very poor results in production.

Fig. 1 shows a fixture built exclusively for hardening the hole only on various types of dies. The bottom casting is held stationery and the top one slides up and down actuated by an air cylinder. Inserted in these castings are high speed steel ring plates with sharp beveled edges surrounding the inside diameter, so as to bite into the die and thus prevent any leakage. (See Figs. 2 and 3.)

The dies are located by an adjustable "V" block so as to obtain proper centering. The top casting is then lowered with full pressure and the quench turned on. The quench flows from the bottom casting through the die and out of the top casting.

The quench pressure must not be too high, otherwise only partial hardening will take place in the hole. In Fig. 4 is an example of too-high quench pressure—note that the hardened areas (darkened) extend only part way down from each end. In Fig. 5 we have an example of correct hardening—note that here the hardened area (also darkened) extends uniformly on all sides of the hole.

A quick way to arrive at the approximate correct quench pressure is to set the cold die on the bottom casting and, without dropping the top casting, turn the quench on. The maximum pressure that does not raise the die off the casting is roughly the quench pressure to be used in actual production.

There are, therefore, three very important precautions to be observed in order to harden a cartridge die properly:

(1) There must not be any leakage.

(2) The quench must not be too cold (the correct temperature is approximately 80 to 90 deg. F.).

(3) The quench pressure must not be too high.

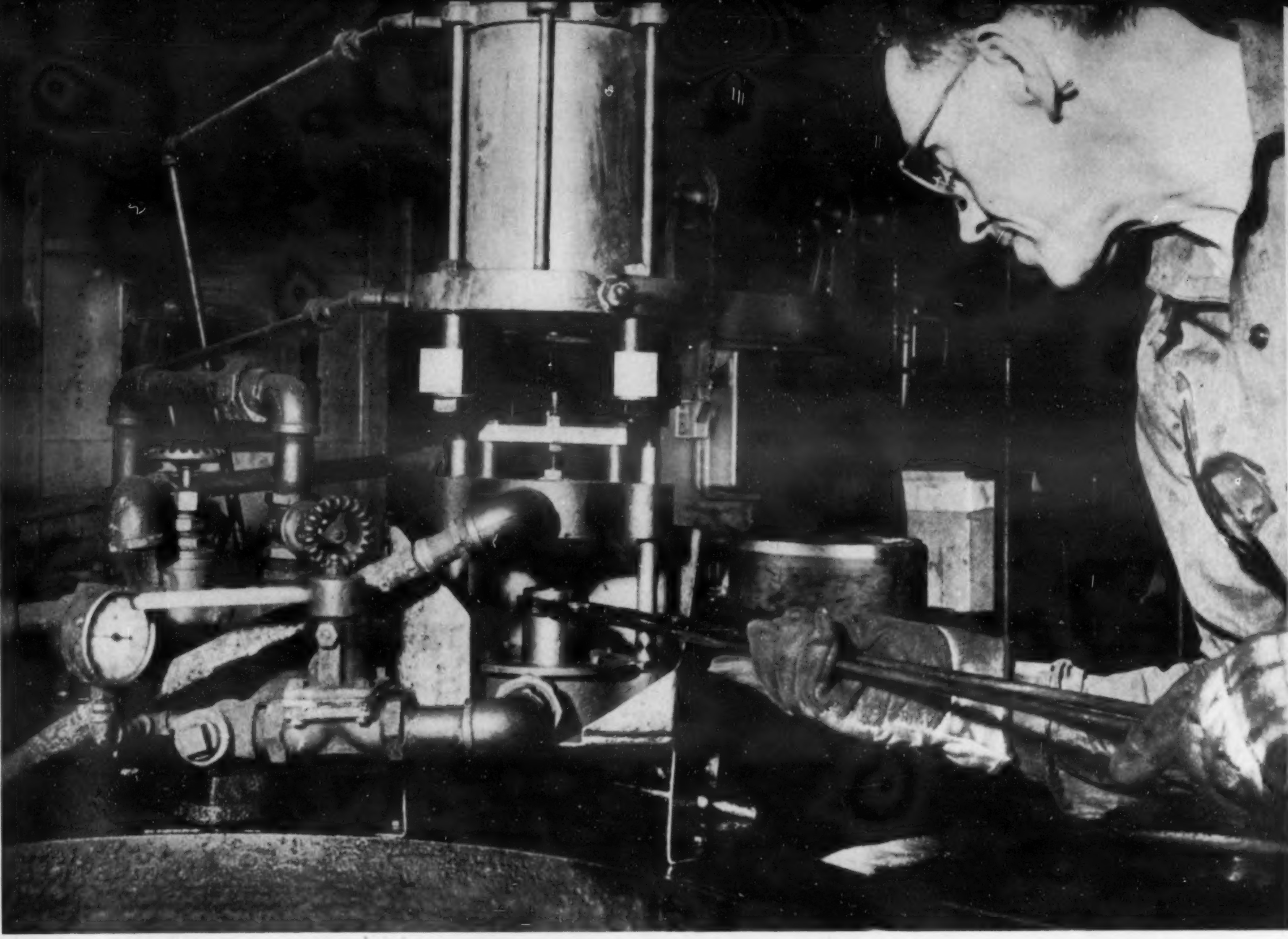
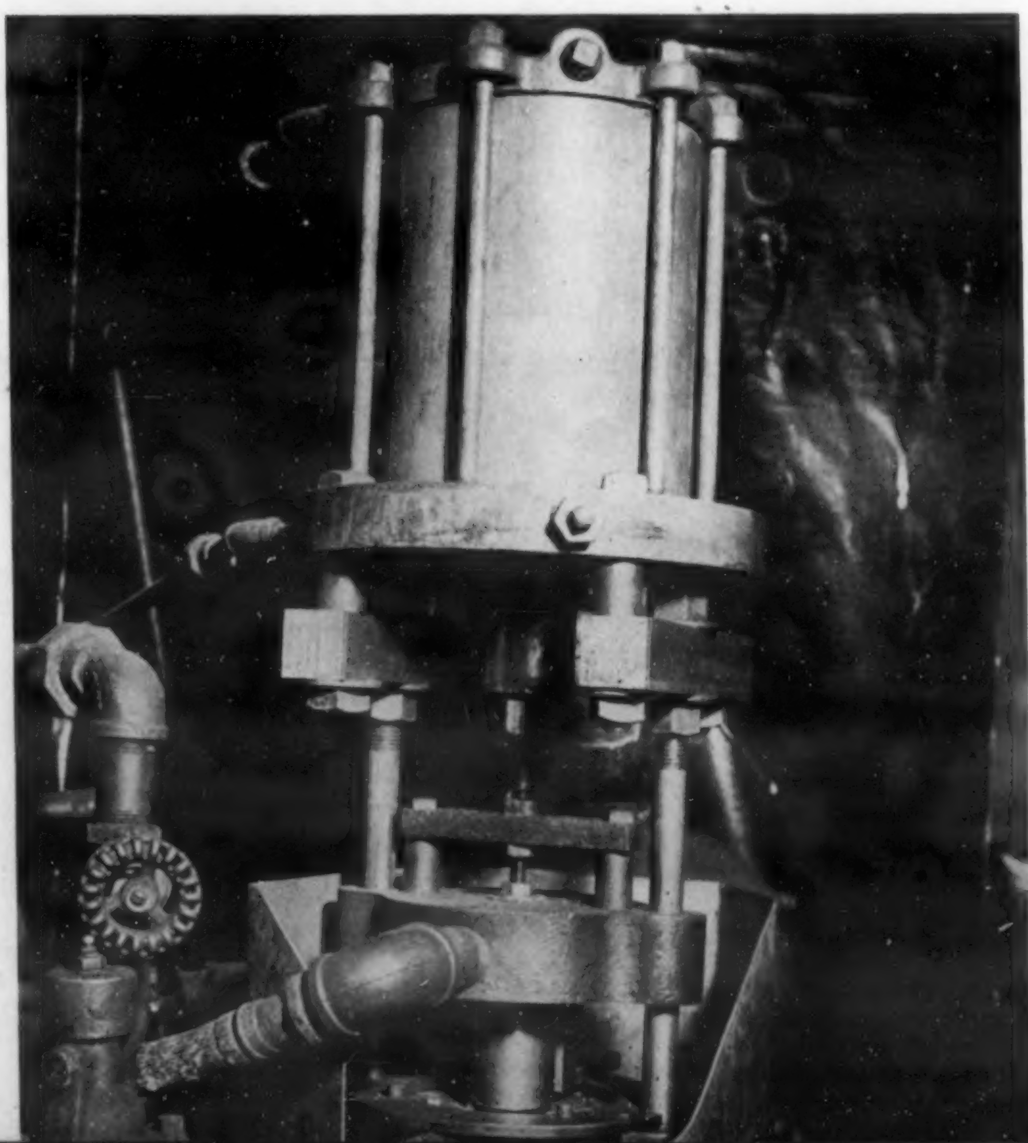


Fig. 1. Placing a hot die in the quenching fixture.

Fig. 2. A closeup of the quenching fixture as the air cylinder grips the hot die firmly for the quench.

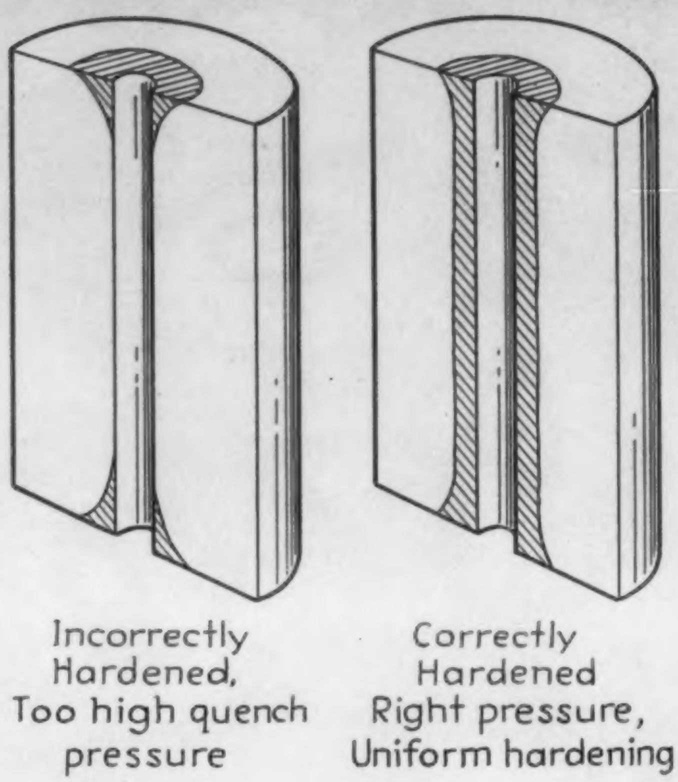


Punches

The hardening of cartridge punches has been a very difficult problem throughout the country. The main difficulty is to keep the punches straight in hardening. In order to maintain production rates, most of these punches have been made of a straight-carbon water-hardening tool steel.

Probably everyone knows that because of the drastic quench necessary to get full hardness of this type of steel, it is almost impossible to keep it straight. Contrary to many beliefs, these punches do not warp in the heating. Experiments have been made in which parts were placed in a furnace at 1800 deg. F. without any preheat and then checked on centers while still hot and no warping was experienced.

Also, parts were suspended in the same furnace over a fulcrum at the center point in an attempt to make the part sag with its own weight. The



Figs. 4 and 5. Incorrect and correct hardening.

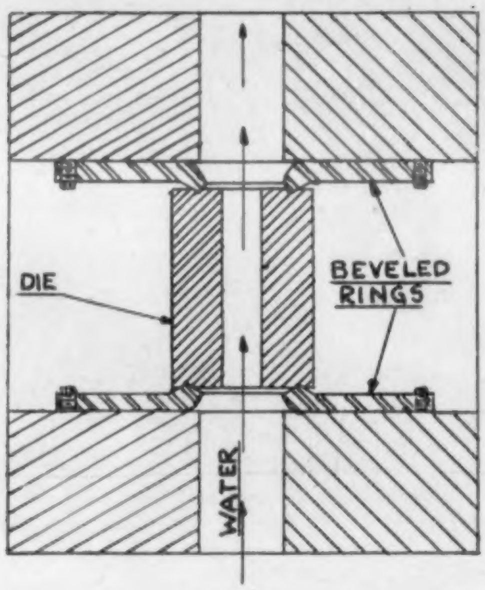


Fig. 3. Cross-section showing operation of quenching fixture. Note beveled rings, which provide a water-tight seal between die and fixture.

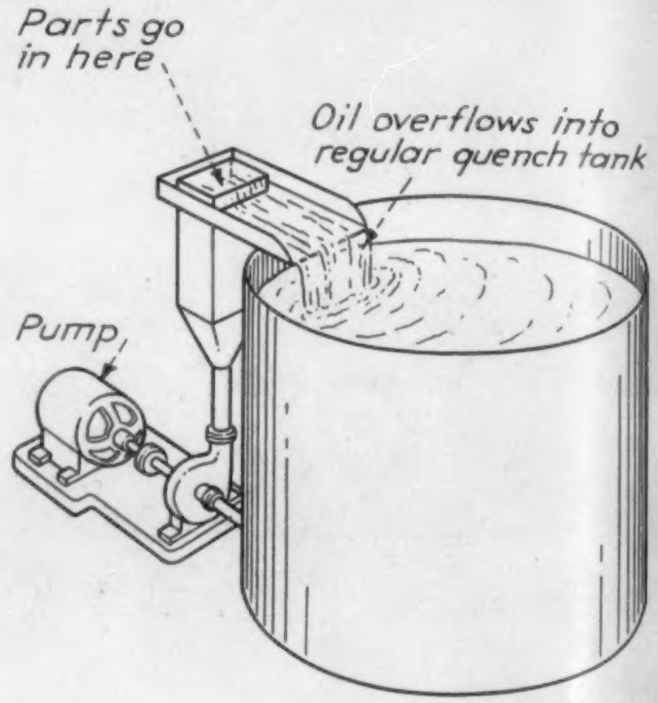


Fig. 6. Flush-quench tank, designed to prevent gas - formation during quenching.

part was also checked for straightness while hot and no distortion was experienced. The reason for the extremely high temperatures was to get the worst possible conditions in heating in order to prove whether warping occurred in heating or in quenching.

After this discovery, it was decided that if the ideal quench were used, distortion could be eliminated. And after many heartbreaking (and also punch-breaking) hours, we found that if the punches entered the quench tank in a vertical position while spinning at 1700 r.p.m., distortion was cut down 50 per cent.

However, because of gases forming non-uniformly along the punch, the ideal quench had still not been found, and the warpage persisted. The next step was to have a stream submerged beneath the surface of the quench, which flushed away the gases formed. An additional 10 per cent improvement was immediately noticed. Still it was felt that the amount of distortion could be lessened.

It was then found that as long as there was a stream to "wash away" the gases the temperature of the quench could be raised. Temperatures as high as 105 deg. F. were used without appreciable loss in hardness. We now felt that just about everything possible had been done to eliminate distortion.

However, there still is approximately 10 per cent distorted beyond the tolerance of 0.010 in. but not more than 0.020 in. runout. Although this is not perfect, the condition is no cause for worry, since if the punches are straightened immediately after the quench, there is very little likelihood of their breaking. But if the parts lie around any appreciable length of time (2 hrs. or more), they are practically impossible to straighten.

Some punches are so small that if quenched in brine or water they will develop quench cracks. On the other hand many heat treaters have been unable to get full hardness by quenching in oil. The remedy found was to heat in an atmosphere furnace in order to keep the parts absolutely clean for quenching; if any type of film or scale were present on the part from heating, the quenching effect of the oil would be slowed enough to prevent the attainment of full hardness.

As an added precaution, a very useful flush quench was built (see Fig. 6) wherein the parts were set into a small quench-basket fed by oil from a pump. In this way cool oil is made to flow by the punches, and any formation of gas is prevented. Parts up to ½ in. in diam. made of water-hardening tool steel can be hardened to 64-66 Rockwell C in oil by quenching with this method, and with practically no distortion.

"Production for Victory"—Theme of Conference

THE ANNUAL MEETING OF OPEN-HEARTH AND BLAST FURNACE OPERATORS

By EDWIN F. CONE

"More Production for National War Demand" was the theme of the annual gathering of open-hearth and blast furnace operators this year. It is the annual custom of the Open-Hearth and Blast Furnace and Raw Materials Committees of the A.I.M.E. to hold a joint conference and the one this year met at the Netherland Plaza Hotel in Cincinnati, Ohio, April 16 and 17. When it is realized that at least 90 per cent of the American steel output is made in open-hearth furnaces, acid and basic, the importance and significance of such a meeting cannot be over emphasized under the present conditions of all-out production of both steel and pig iron.

The conference was an inspiring one and demonstrated that the men in the American steel industry are fully alive to the present menace to our safety and the preservation of our liberties; that this is a War of Steel—steel for ships, tanks, guns and airplanes. An outstanding conviction of this observer is that there exists in the industry a will to cooperate not only in all-out production but in the exchange of information and experience among large and small producers that will in any way further the war effort. Such a spirit is vital to the winning of the war.

The conference demonstrated the value and the necessity of such a meeting. It was generally agreed that these conferences should by no means be adjourned during the war.

In this report an attempt is made to present a few of the many highlights of this memorable meeting—not the largest ever held but one of the largest, with an attendance of close to 700 of both open-hearth and blast furnace men.

The Open-Hearth Conference

In his opening address to the open-hearth conference, Leo F. Reinartz, general chairman of the National Open-Hearth Committee stated that, in the organization of this year's meeting, the executives of all the large and small steel companies had been approached. The request was made that operating men be granted time off to attend, so as to swop experiences, share data and increase output. Intensive co-operation of "big and little steel" was the result.

Most of the open-hearth session programs are topics and discussions—very few set papers; hence the sketchiness of this report.

Hot Metal and Iron Ore Charges

One of the most important topics to come before the Conference was the use of high hot metal charges from the blast furnace. With the supply of scrap on the decline, an increase in the iron content of the open-hearth bath is a decided desideratum and necessity. If the pig iron or hot metal charge is increased, more iron ore to reduce the increased quantity of carbon present is a factor as well as the addition of more carbon as coke, coal, etc. It was emphasized that if by some such successful practice, the yield of steel can be increased about 2 per cent, our output of ingots can be augmented by at least 1,500,000 tons per year.

Opinion was unanimous that the principle involved is sound. The main problem is how best to use the iron ore—whether as soft ore, as briquetted fines, or

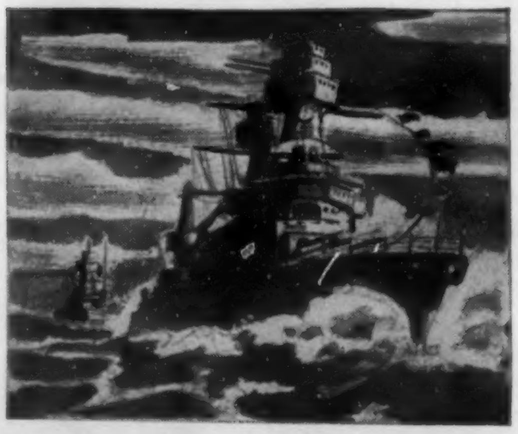
(Continued on page 786)

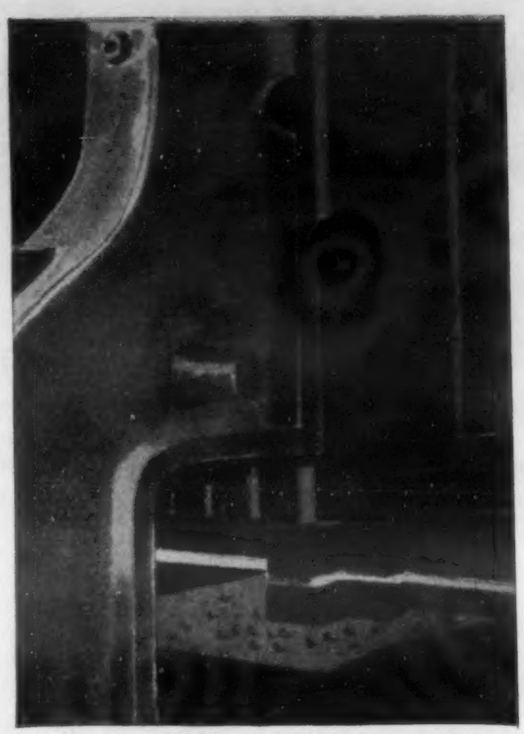
A group of operating men at the annual Open-Hearth and Blast Furnace Conference (left to right): W. P. Albaugh, superintendent of open-hearth, American Rolling Mill Co., Ashland, Ky.; C. R. FonDersmith, superintendent of the open-hearth, American Rolling Mill Co., Middletown, Ohio, chairman of the arrangements committee; F. M. Andrews, secretary of the Andrews Steel Co., Newport, Ky., Rudolph Tietig, Jr., general superintendent, Andrews Steel Co., vice chairman of the arrangements committee; R. S. Bower, superintendent of open-hearth furnaces, Andrews Steel Co., and Frank T. Sisco, secretary, open-hearth committee and the metal divisions of the A.I.M.E., New York.

• **VANADIUM** — an indispensable alloy in high speed steels that carve out guns, gears, shafts, armor plate—an element in the finest springs and in heavy steel castings of high quality—essential in many of the best forging steels for both heavy and light sections—contributes strength, toughness, ductility, resistance to impact, wear resistance, uniform internal structure, machinability, weldability—simplifies heat treatment, inhibits grain growth, adds hot hardness—

• **CHROMIUM** — hardener of steels and irons—essential element in all stainless steels—principal alloy of the SAE 5100 series—partner with other alloys in a long list of the best forging and structural steels—goes into practically every field — shafts, gears, structural tubing, heat-resistant tubing and castings, chemical equipment, cylinder blocks, springs, automotive and aircraft forgings—

• **SILICON**—deoxidizer and degasifier in open hearth, bessemer, crucible and electric steels—graphitizer in cast irons





—essential alloy in many sheets and other shapes for electrical applications—major component of many spring, tool and corrosion-resistant steels—minor component of all carbon and alloy machinery, automotive and aircraft steels—was the leading tonnage alloy of 1941—

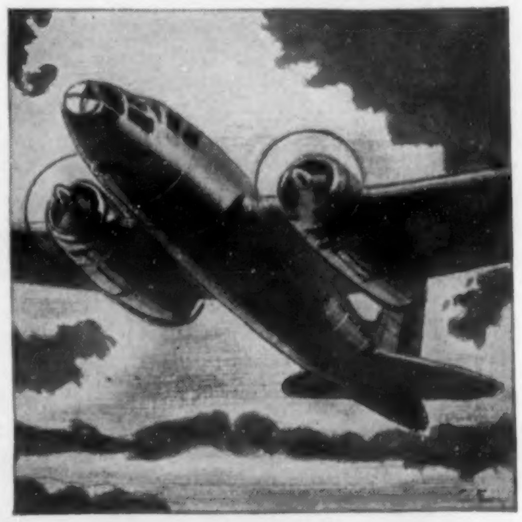
• **ALSIFER**—(aluminum silicon iron alloy)—deoxidizer for all quality steels—perfect addition for the production of fine-grained steels—contributes uniformity of hardness and control of grain size, gives higher aluminum efficiency—

• **TITANIUM** — deoxidizer and cleanser in rimming steels—gives smoother surface and freedom from sub-surface defects in sheets and other rolled shapes—as deoxidizer, scavenger, and alloying element, is added to steel castings, fully killed ingot steels—in high chromium corrosion-resisting steels, is a carbide stabilizer—

• **GRAINAL ALLOYS**—ladle or ingot additions that greatly increase hardenability even in fine-grained steels—usually increase hardenability, toughness and impact resistance simultaneously — make carbon and alloy steels usable in larger sections—

• **V-FOUNDRY ALLOYS**—(chromium silicon manganese alloys)—reduce depth and variation in depth of chill in cast iron—stabilize and slightly increase tensile strength—improve machinability with same or slightly increased hardness—eliminate hard spots—

• **GRAPHIDOX**—graphitizer in cast irons—powerful agent, even in very small quantities, for converting white into gray iron—eliminates hard spots, re-



duces and stabilizes chill depth in plain or alloy irons—provides unusual control where properties must be improved without increase in hardness—

• **SPECIAL ALLOYS**—to meet individual requirements.

ADIUM

FERRO-ALLOYS

Part of the group at the speakers table at the Fellowship Dinner (left to right): Col. Fred A. McMahon, head of the Cincinnati Ordnance District; Charles R. Hook, president of the American Rolling Mill Co.; Vice Mayor of Cincinnati Willis D. Gradison; Bennett Chapple, assistant to the president, American Rolling Mill Co., toastmaster; L. F. Reinartz, chairman of the open-hearth committee, and Lieut. Com. W. D. Bartlett, inspector for the naval materials office in charge at Cincinnati.

as sintered ore. This is not a new problem for it developed that several of the large companies, having hot metal available, have been using some such practice for some time. Differences of opinion as to the best way to use the ore without reducing output of steel were in evidence.

The American Iron & Steel Institute's committee on steel appointed a subcommittee on this subject in March. Some 21 open-hearth plants are included in a survey. Considerable work has been done, Dr. Herty reported, but it is by no means complete. The main problem has been—how much soft ore can be used and not decrease output. The use of sintered ore is better in the blast furnace. While the use of sintered ore in the open-hearth is advantageous, the supply is inadequate and the building of enough sintering equipment is a problem.

The use of partially reduced iron ore which has been treated in kilns is a factor also. In this way the ore is still used as an oxidizer at the same time adding more than the usual amount of iron to the bath. Some pre-treatment of the iron ore is not only advantageous but in many cases necessary.

In Australia, hot metal charges with iron ore have been the practice for 15 or more years, said L. B. Lindemuth, consulting engineer, New York. Hot metal charges as high as 80 per cent are used with prepared ores. An advantage of briquetted soft ores is that there is a better chance of drying the ore. Hard ore should be screened to remove the fines. It was our impression that prepared ores—briquetted or sintered—are preferred by Mr. Lindemuth to increase output. The problem of securing the 10,000,000 tons of iron ore needed to fully carry on this practice in the United States is a difficult one.

While this whole problem of increasing production by high-hot metal charges is a highly important one, it is evident that practice in this country has not yet been fully coordinated. Many problems are to be solved with the future of the scrap supply a large factor. It was evident that an earnest study by all concerned was being carried on.

Conservation of Materials

The conservation of three important steelmaking materials—manganese, aluminum and scrap—were discussed at one of the sessions.

Manganese: Intensification of the saving of this vital element was highly stressed by several speakers. Dr. Leach of the W. P. B. said that while we are not now short of manganese, we may be if the war continues for some time—depending on developments in the shipping situation. A time may come when we may have to do without all we need.

The American Iron and Steel Institute has thoroughly studied the manganese situation, said Dr. C. H. Herty, Jr. In 1940 the consumption of this metal was about 12½ lbs. per net ton of steel produced. Since then the amount of high manganese steel made has increased while the quantity of low manganese steel has decreased. But in February of this year the consumption was still about 12½ lbs. per ton. Much has been done in conservation of manganese but there is still much to be done. Specifications for manganese have been lowered to less than normal. Cooperation between both producers and consumers is highly essential.

By great care in steelmaking practice and by improved heat treatment of the steels produced, some conservation of manganese can be and is being attained, according to C. E. Williams, director of Battelle Memorial Institute.

Increases in the quantity of residual manganese in the steel bath was urged as decidedly important by several operating men and by metallurgical engineers. It was emphasized that this can be done. Lowering of the specifications for manganese by 3 to 5 or even 5 to 10 points is essential and feasible without sacrifice of factors of safety in many cases. Also changes in deoxidation practice, by the use of more spiegeleisen for example, was cited. No substitutes for manganese were reported.

Aluminum: All recognize the important role that this metal plays to attain certain results. Data of the American Iron and Steel Institute show that from late in 1940 to January in 1941, the average consumption of aluminum per net ton of steel ingots was about 0.70 lb. By late in 1941 this had been lowered to 0.54 lb. per ton.

Various possible substitutes were discussed—silicon, titanium, boron and so on as deoxidizers. Silicon has been substituted by not for grain size control. The use of "Razorite"—really a crude borax—was advocated by some as a substitute but only in making rimming steel. In low carbon steel about 2 lbs. of "Razorite" for 1 lb. of aluminum was mentioned.

Scrap: The presence of tin in scrap came in for active discussion. One speaker forcibly called attention to the present practice of scrap dealers in hiding tinned scrap inside bundles of scrap steel. This should be stopped so that the tin scrap can be used advisedly. The rejection of all such material was urged by several. The presence of tin in steel can be dangerous, especially in producing deep drawing steels.

Segregation of low alloy or all alloy steel scrap was forcibly advocated by Earle Smith, chief metallurgist of Republic. Under present conditions there is a decided waste of some valuable metals such as nickel. High residual copper was also cited. Unless more care is exercised in the segregation of alloy scrap, there is some danger of the necessity of the shutting down of electric steel furnaces. The presence of tin in steel both for hot rolling and for welding should be guarded against. Our duty in segregating alloy scrap, high or low, was seconded by Dr. Herty of Bethlehem, particularly from the standpoint of our deficiency in alloys.

[An article by W. J. Reagan on "Conservation of Alloys in the Open-Hearth" on other pages in this issue is recommended in this connection.]

The Government's Expansion Program

The conference was deeply impressed with a recital, by a representative of the War Production Board, of the Government's plans for further expansion of the steel industry. Details of this program were outlined in an "off the record" presentation at one of the sessions. That it is "staggering" is no exaggeration.

Pointing to the fact that, in the early days of the Defense Program in 1940, said the speaker, some authorities in Washington correctly read the signs of the time and urged expansion while others were against it—not until "Pearl Harbor" was it realized by nearly all that the United States is the principal target and that this is a War of Steel. "The nation that can make the most steel will win the war and this

(Continued on page 788)

group of operators can do the job." It is the biggest job of steel and iron expansion ever undertaken anywhere.

Among the suggestions to attain this were the maintenance of continuous output of both pig iron and steel, cutting the ordering of spare parts to the bone, ordering only what is necessary to increase tonnage, making all the repairs that are possible and using wood, concrete and so on, whenever feasible. Hoarding of materials, except possibly brick, is to be avoided, he said.

"Ships and more ships, guns and more guns, tanks and more tanks is the war cry. Given these and other necessities, Yankee ingenuity will win."

At the same session the question as to the trend of delays in open-hearth production under present extended full operations was discussed. It was emphasized by several that delays are frequent, due to charging difficulties occasioned by inferior scrap. It was interesting to note, however, that better results in the use of light scrap were being experienced than had been expected, according to the testimony of several operators.

Refractories and Construction

Again at the session of the basic open-hearth operators on "Refractories and Construction," the dominant note was "Production for Victory."

It developed during the discussion that "Ramix" is extensively used in making furnace bottoms. H. N. Barrett, Jr., of Basic Refractories of Cleveland, presented with slides a description of how this material may best be handled in preparing furnace bottoms. It was brought out in the testimony of more than one operator that this material is giving satisfaction and that it is usually put in at varying thicknesses with different materials as coverings, such as "KN," magnesite and so on.

A few operators reported that some of their furnaces are being definitely enlarged by increasing the length and/or the width by the use of Ramix. Larger heats are the result.

"Sta-Set" came in for favorable consideration. Important testimony was forthcoming that this material is not only being used for furnace bottoms but in the rapid repairing of a breakout, thus saving lost time in getting out the steel.

The life of a furnace can be increased 22 per cent, according to the experience of one company, by using longer brick in the roof of a furnace, here again resulting in more production.

The output of an open-hearth can be expanded about 50 heats by using soot blowers to clean out the checkers at one large plant. Great importance is attached to the maintenance of clean flues—this was emphasized more than once.

The Spectrograph and Other Tools

Strong evidence was forthcoming at one session that the spectrograph is vital in saving time and thus increasing production.

In analyzing the steel bath for certain metals such as copper, tin, chromium and so on, the time required by conventional wet or other methods varies widely—sometimes 5 hrs. before tapping. This often means delay. The spectrograph gives the answer in a fraction of the time.

A representative of one large steel company testified that visits were made to several plants using the spectrograph with the result that a Dietert outfit was installed last July. By fall analyses for such elements as tin, copper, chromium and so on were made in less than 25 to 30 mins. as against 1 to 1½ hrs., previously. One man in each shift turns out 4,500 to 5,000 determinations a month. All lost time is eliminated and the equipment has paid its way.

From the Carnegie-Illinois Steel Co. came testimony corroborating that just cited. The Gary plant has a spectrograph and is developing its use rapidly.

The high dispersion value of the Bausch & Lomb spectrographic equipment was emphasized by Mr. Nitchie of that company and the practice and experience of the Ford Motor Co. and the Bethlehem Steel Co. were cited. J. L. Gregg of Bethlehem reported the use of this equipment for copper, tin, chromium, molybdenum, nickel, etc., as a great time saver.

Both the photolometer and the Leco machine for sulphur and carbon were favorably discussed and emphasized as time savers by representatives of Carnegie-Illinois and Wisconsin Steel—all vital in

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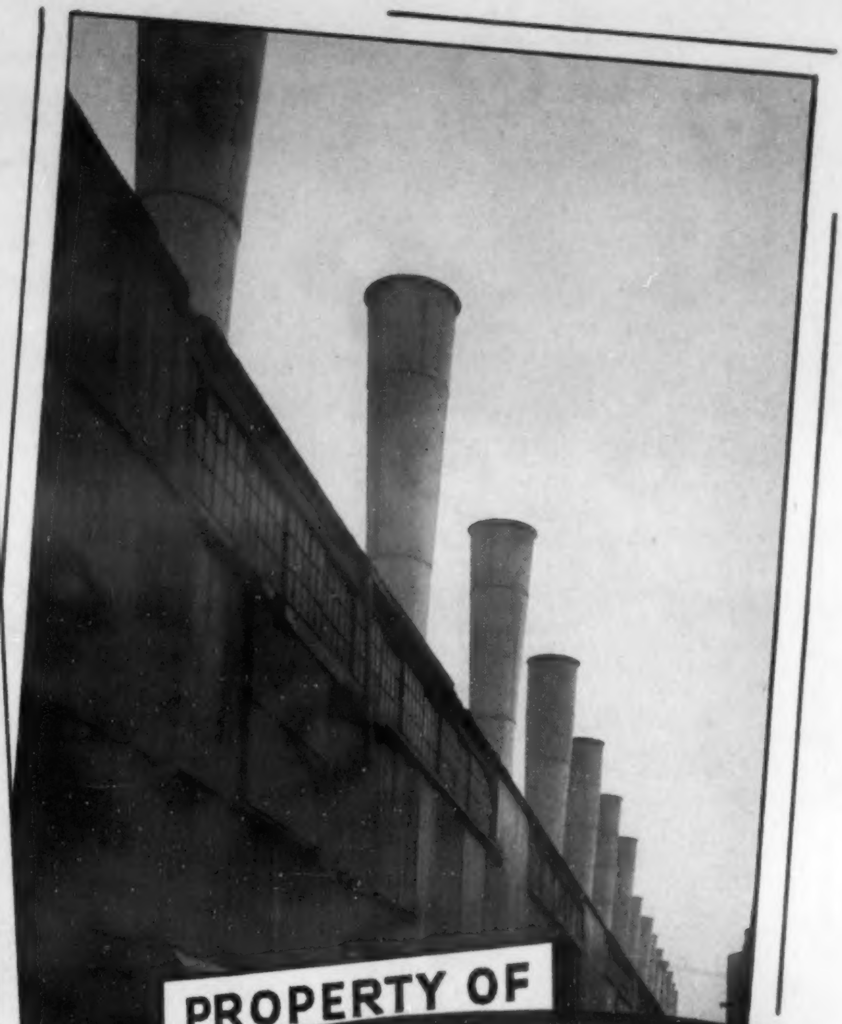

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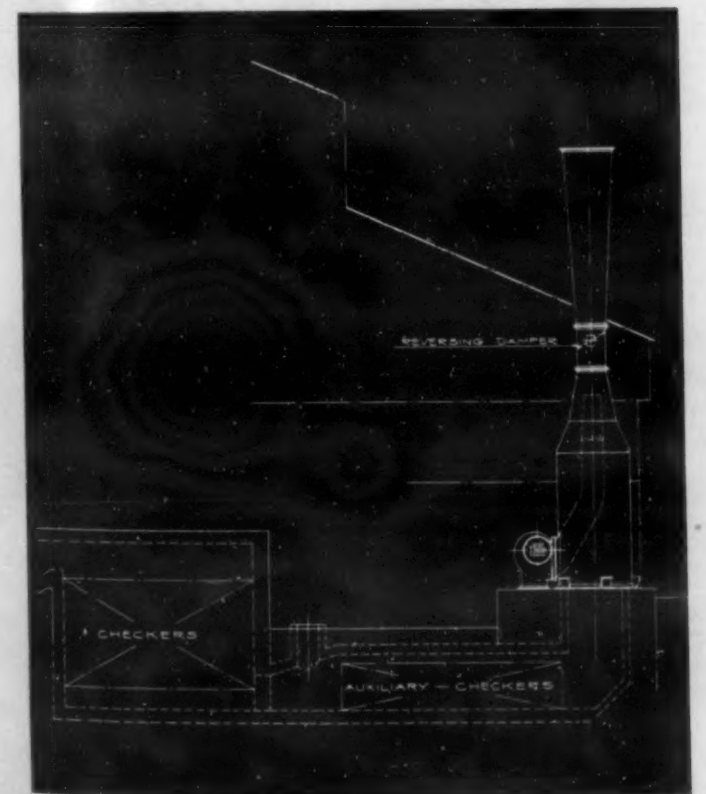

V-35

Morgan Construction Co.
Worcester, Massachusetts

European Representative: International Construction Co., 56 Kingsway, London, W. C. 2,— England

but the results are OUTSTANDING

Compare these photographs with those of any old-fashioned open hearth installation! Note the *absence* of high stacks and the substitution of the short venturi tubes of the Isley Regenerative Combustion Control system. Think of the *savings* in installation and maintenance costs; the all-important *time* earned for extra production. Consider the *economy* in labor and material . . . all these are apparent in these pictures.

But the real reasons for twelve years of ISLEY expansion by this company are found *inside* the plant. For with Isley Regenerative Combustion Control the company has increased the temperature of its combustion air with enlarged regenerative capacity.

It has obtained greater efficiency from fuels, closer control of furnace temperatures, with more tons per hour and more heats per campaign. It has assured uniform operation of each open hearth—day or night, winter or summer, regardless of outside temperature and humidity.

The full ISLEY story is told very simply—practically at a glance—in our new bulletin "Push and Pull." Write for a free copy.

ISLEY Regenerative Combustion Control

A Poem

Bennett Chapple, toastmaster at the annual fellowship dinner, inspired by the poetic muse, read the following poem to the diners. It was heartily received.

To Men of Molten Steel

Here's to the men of molten steel,
Men who fight with heat and flame,
Who serve the world with iron brew
With few to sing their fame.

Every ship and tank speeds forth,
Every cannon's roar,
To meet our challenged liberty
Comes from that furnace floor.

With naked waists their uniform,
They wear no shoulder straps,
But mighty implements of war
Are born in furnace taps.

War is grim, and so are they—
These warriors of the molten world,
Who fight for Victory to keep
Our Freedom's flag unfurled.
—Bennett Chapple

boosting production. A representative of one of these companies said that they are using a combustion method for sulphur in ½ mins. and have developed a rapid analytical procedure for manganese. Both carbon and manganese can be determined in 9 to 12 mins. with phosphorus in 18 to 30 mins.

The Fellowship Dinner

Over 450 enthusiastic blast furnace and open-hearth superintendents, metallurgists and metallurgical engineers, executives, refractory manufacturers and others sat down to the Annual Fellowship Dinner, Thursday evening, April 16. This followed a reception where conviviality reigned supreme, the compliments of the Open-Hearth Executive Committee.

Presiding as toastmaster, the genial Bennett Chappel, assistant to the president of the American Rolling Mill Co., introduced representatives of the Army and Navy who spoke their respective speeches. This was followed by a ringing address by C. R. Hook, president of Armco.

Mr. Hook fervently emphasized the absolute necessity of wholehearted cooperation of industry, labor, and all concerned in the present gigantic task. "We note with regret the growing tendency to attempt to pin guilt for alleged misdeeds upon certain corporations without full and conclusive evidence. As a result, many injustices are being done and public morale is being harmed. While there will undoubtedly be a few business men who will attempt to use the war to further their own interests, they constitute only a small minority. The great majority are fair minded, patriotic and faithful to their trust."

Prizes: A highlight of the evening was the presentation by Chairman Reinartz of the Open-Hearth Committee of the awards established in memory of Frank McKune,

Menu at the Banquet

Bar Mill Cobbles
Silica Wash
Ladle Brick Splits
* * *
Runner Scrap
Raw and Burnt Refractory
* * *
Molten Slag
Scabs
* * *
Bottom Skull and Hot Metal
Hydraulic Bundles
No. 2 Steel
* * *
Loose Clippings, Ingot Butts and Sheet Scrap
Good Melt Down
* * *
Special Graphite Stopper Heads
Hot Patches
Carbon Kicker

a Canadian open-hearth superintendent and founder of the Conference in 1925. The first prize of a certificate and check for $100 went jointly to H. B. Emerick and Simon Feigenbaum of the metallurgical department of Jones & Laughlin Steel Co. for their paper—"Duplex Process for the Manufacture of Open-Hearth Steel"—delivered at one of the sessions. Second prize of a $50 war bond went to Jacob T. Maner, Wisconsin Steel Co., while Roy W. Tindula, Republic Steel Co., Buffalo, won third place with a $25 war bond.

(Continued on page 791)

The Blast Furnace Conference

By T. L. Joseph

Until the output of blast furnaces now under construction becomes available, it is particularly important to get the maximum tonnage from every furnace now in operation. Problems arising from the use of larger than customary proportions of pig iron in the open-hearth charge can be met if the hot metal is made available. The shortage of steel scrap will require a rapid expansion in the production of all raw materials, additional blast furnaces, and the most effective use of existing equipment.

These were some of the important facts developed at the conference of blast furnace and raw materials committee. Several prepared papers were part of these sessions.

Preparation of Ores

Developments during the past decade have demonstrated that improvements in the physical properties of raw materials is the most effective means of increasing the output from existing furnaces. Problems connected with the size preparation of Lake Superior iron ore were discussed in a paper by E. W. Davis of the Minnesota Mines Experiment Station. To prevent clogging of screens, many ores will require partial drying for separation of the smaller sizes which are the most objectionable. The saving in freight would partly offset drying costs, but sizing operations will increase the cost of ore and necessitate more storage piles for the various sizes which will differ in chemical analysis.

Ben. Harlan stated that he had obtained excellent results at the Lackawanna Plant of the Bethlehem Steel Co. by screening out the fines from certain ores, sintering them and charging the sinter with the oversize and untreated ores. The presence of the coarse ore and the sinter results in a substantial increase in output and a decrease in fuel consumption. The consensus of opinion seemed to be that coarse sizes of Mesabi ore are more effective than an equal weight of sintered Lake ore fines in stepping up production.

In addition to screening all or a portion of ores containing excessive amounts of fines, the practice of shipping fine concentrates in separate cargoes and sintering them at the blast furnace received favorable comment as another step towards improving the structure of Lake ore. The Jones & Laughlin Steel Co. plans to extend this practice which has been followed for several years.

Some Coke Problems

Since coke comprises about two-thirds of the volume of the charge, the effect of its physical characteristics in producing a permeable column that will permit higher volumes of air is well recognized. Charles C. Russell of the Koppers Coke Co. discussed the classification of coals and laboratory tests for measuring coking properties.

Laboratory tests developed comparatively recently to measure the properties of coals in the plastic stage were discussed and data presented to show the variations that occur with changes in volatile matter and varying degrees of crushing. Because the cell structure of the coke is determined by the properties of the plastic mass which marks the transition from granular coal to immature coke, this more fundamental approach to coking problems provides another tool for making the best use of the coals available for blending.

Robert B. Sosman described the equipment used for measuring the temperature of the coke as it is pushed from the oven. With such information it is possible to determine whether the coke has been heated to normal temperatures and the uniformity of heating from one end of the oven to the other.

Blast Furnace Flux

A paper presented by T. L. Joseph showed that blast furnace flux varies widely in rates of calcination. Dolomites calcine more rapidly than dolomitic limestone, while high calcium stones calcine at the slowest rate. Crushing to smaller sizes, particularly in the case of high calcium stones, was recommended to permit complete calcination above the bosh and to create greater permeability in denser portions of the stock.

In surveying the type of ore that may be expected during the next 10 to 15 yrs., C. L. Wyman pointed out that a rapid ex-

(Continued on page 792)

pansion in output, now well under way, will markedly deplete reserves of direct shipping ore and increase the use of beneficiated ore. Future material will be somewhat higher in silica and definitely lower in alumina.

Methods of grading iron ore and the problems which the ore grader must contend with were discussed in a paper by Norman H. Thomas of Pickands Mather Co. From the discussion that followed, there seems to be little doubt that the average cargo analysis is reasonably close to the guaranteed analysis so that an equitable basis for determining the value of the ore is provided. Furnace operators contended, however, that variations in the silica content of different portions of a cargo carry through to the blast furnace, making it difficult to control the basicity of the slag and the sulphur in the iron. Due to the large tonnages of ore involved, it is obviously difficult to determine the true status of the problem.

Use of Powdered Lime

The introduction of powdered lime through the tuyeres as a means of slag control was discussed by Carl G. Hogberg, secretary of the Blast Furnace & Coke Committee of the Carnegie Illinois Steel Corp. Many plants, forced to purchase outside coke, are confronted with wide variations in ash. Because this ash is not released above the tuyeres, wide variations occur in the composition of the slag formed in the bosh of the furnace from the basic oxides in the stone and the acids in the ore. The elimination of these variations is one of the advantages to be gained by introducing, through the tuyeres, the lime required to flux the coke ash. Moreover, with this application of flux, the more acid slags formed in the bosh would permit faster rates of operation. Results of this innovation in practice will be looked forward to with great interest.

Variations in the permeability of the stock from the inwall to the center result in differences in gas flow, gas composition and temperature. James M. Stapelton, assistant superintendent of Blast Furnaces at the South Chicago Works of the Carnegie-Illinois Steel Corp., presented an outstanding paper on the results of surveys of the composition of gas emerging from the top of the stock at various positions from the center to the inwall of a number of furnaces. The highest ratios of CO to CO_2 were at the inwall with a gradual decrease towards the center for about 2.5 ft., followed by an increase in the center of the furnace. Low ratios of CO to CO_2 in the periphery, which represents a large portion of the total area, were obtained when the furnaces were operating upon the least fuel and producing the greatest tonnage. Changes in the sequence of filling, speed of bell drop, and height of stock were found to affect the composition of gas at various distances from the inwall to the center.

Design and Construction

The closing session was devoted to a discussion of Furnace Design and Construction. Arthur G. McKee discussed the advantages of having a large annular space to reduce the velocity of the gas and the production of flue dust, particularly during the interval when the charge is moving off the large bell into the furnace. He suggested enlarging the diameter of the furnace above a position about 4 ft. below the level of the large bell when closed. The trajectory of stock moving off the bell is such that it would be deposited below the level at which the stock line is enlarged. Such an enlargment should not, therefore, affect the arrangement of stock, which in turn influences the distribution of the gas.

The tendency in top design is towards large stock line diameters, ranging from 20 ft. 6 in. to 21 ft., to permit low gas velocities through the charge and thus curtail dust losses. Large off-takes and a large annular space resulted in very low dust losses on furnaces for which operating data were available. Low slag volumes, high alumina slags and the shipment of coke from the Atlantic Seaboard in to the Pittsburgh district were suggested as ways of maintaining production rates at high levels.

Many of the most important features of blast furnace design were discussed by A. L. Foell, chief engineer of Arthur G. McKee & Co. Hearth diameters of modern furnaces range from 25 to 28 ft. Proper

(Continued on page 793)

"Skimmings"

C. H. Herty, Jr., in his new capacity as assistant to Quincy Bent, vice president in charge of operations of the Bethlehem Steel Co., was receiving congratulations and best wishes. ————

American flags in profusion and Victory buttons and labels were on display everywhere.

————

Frank Sisco, the friendly secretary of the metal divisions of the A.I.-M. E., has assumed new duties. Clyde Williams has resigned as secretary of the open-hearth committee and Frank takes on the work.

————

As chairman and co-chairman of the various sessions, both open-hearth and blast furnace, prominent operating men of steel companies, big and little, were in evidence.

————

For the first time in some years, there was no joint open-hearth and blast furnace session. Not time enough.

————

Designating labels on coat lapels were easily readable because of the large type—a great convenience for those of us who do not readily recall names.

————

No rationing of sugar at the banquet nor on the hotel tables. Full bowls were prominent.

————

The usual sprinkling—or shall we say prominence—of editors was observed. Knox of Steel, *Lippert of* Iron Age, *Wisbowski of* Industrial Heating, *Longenecker of* Blast Furnace and Steel Plant, *Kelley of* Iron and Steel Engineer, *and your editor.*

————

Ralph Sweetser was missed by many. This cheerful ex-chairman of the Blast Furnace Committee has been active at these meetings for years.

————

A representative of E. F. Houghton of Philadelphia was conspicuous as a voluntary substitute for the soloist at the Fellowship Dinner. He has "some voice."

————

"Razorite" was discussed at one session as a partial substitute for aluminum in making rimming steels. It is really only crude borax, we were told—perhaps the old "20 mule team" brand. We heard one observation that "Razorite" should be suitable for "cutting" out aluminum.

————

Should the war continue into next year, it is possible that this annual conference will be held on a Saturday and Sunday.

————

Representatives of nearly all the ferroalloy producers were attentive listeners at the session and buttonholers of customers and friends in the lobbies. ————

President Hook of Armco, in his address at the annual dinner emphasized the fact that during 1940-1941 a total of 6,950,000 tons were added to American steel capacity—approximately equivalent to Japan's total steel making capacity.

spacing of tuyeres requires 16 tuyeres for hearth diameters of 25 to 26 ft. and 18 tuyeres for larger hearths up to 28 ft.

Bosh cooling should be kept as low as possible. Furnaces with less than the customary cooling have given good life, indicating that the tendency has been to overcool the bosh. Rigid bell rod construction will keep the large bell concentric with the hopper, thus maintaining control of stock distribution. Such construction also provides a more positive action in opening the large bell.

The importance of decreasing the height through which coke is dropped in handling and during charging was stressed as a means of minimizing breakage. Independent support of furnace tops was suggested as a means of preserving proper alignment of the charging mechanism. These features of design influence gas distribution and furnace performance with respect to output and fuel consumption per ton of iron.

The Next Convention

At a meeting of the Executive Committee on Apr. 18, it was decided to hold the 1943 conference in Cleveland, probably late in April. Leo F. Reinartz was re-elected chairman. The new vice-chairman is A. P. Miller, asst. general supt., Inland Steel Co. Frank Sisco is the new secretary, C. E. Williams having resigned.

METALLURGICAL ENGINEERING news

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The Production Front

by H. R. Clauser
Assistant Editor

After almost three years of world war and after six months of active participation by this country, the painful fact still remains that we are sadly handicapped in the war effort by shortages of materials. Despite lack of a master plan in gearing the nation to armament production, despite indecision, petty jealousies in high places, and frequent failure of those in charge to get facts to guide their thinking, rates of production today are at an encouragingly high level, but our already depleted stocks of metals are being cut into deeply.

Licking the material shortages is *the* critical problem of this war that the metallurgical engineers of this country must solve. For two years executives and engineers have been hard at work on this problem of securing enough material—at first for defense and since Pearl Harbor for total war. The pattern to be followed, which was traced by early priority, materials conservation, and limitation orders was clarified last month when drafts of sweeping orders to curtail virtually every consumer's durable goods item disclosed that the economy of the United States would be indeed a war economy.

The nation's great metal working industries were the first to be made aware of total war economy when the automotive industry's production of its normal product was curtailed. It was a shock, but more followed when succeeding orders of OPM and then WPB turned the refrigerator, washing machine, radio and other huge industries into arsenals for war.

Faced with the cold, irrefutable facts of our supply outlook, the Army and Navy and other government agencies are now cooperating with WPB metallurgical branches. Rigid adherence to the "bible" of the Federal Specifications Board is being outflanked by Army and Navy officers who understand the facts of materials supplies. They are stopping to listen to metal working engineers who have material saving ideas. At the same time they are considering changes in the chemical compositions of many alloys in order to eliminate certain metals, such as nickel, tin and chromium which are practically unavailable. In fact some of the metals are becoming so scarce that the reduction of their use must be made by the Army, Navy, Lend-Lease, and other Governmental agencies if we are to continue to keep a proper balance of materials needed for arms manufacture.

Steel

A year ago the second Gano Dunn report on the nation's steel capacity was ridiculed for the gloomy picture it painted—sharply contrasted to his report of three months earlier. It was, indeed, a dark and sombre picture, but in the light of developments during the past twelve months all now agree that it was not gloomy enough.

Although steel production records are being broken continually, there still is not enough steel to go around. Steel plate shipments in March set an all-time record of 878,726 tons while deliveries from strip mills totaled 306,195 tons a substantial increase over February's total. At the same time deliveries to shipyards for the Maritime Commission's merchant ship program increased 30 per cent in March over February. The April deliveries are estimated to equal the March total.

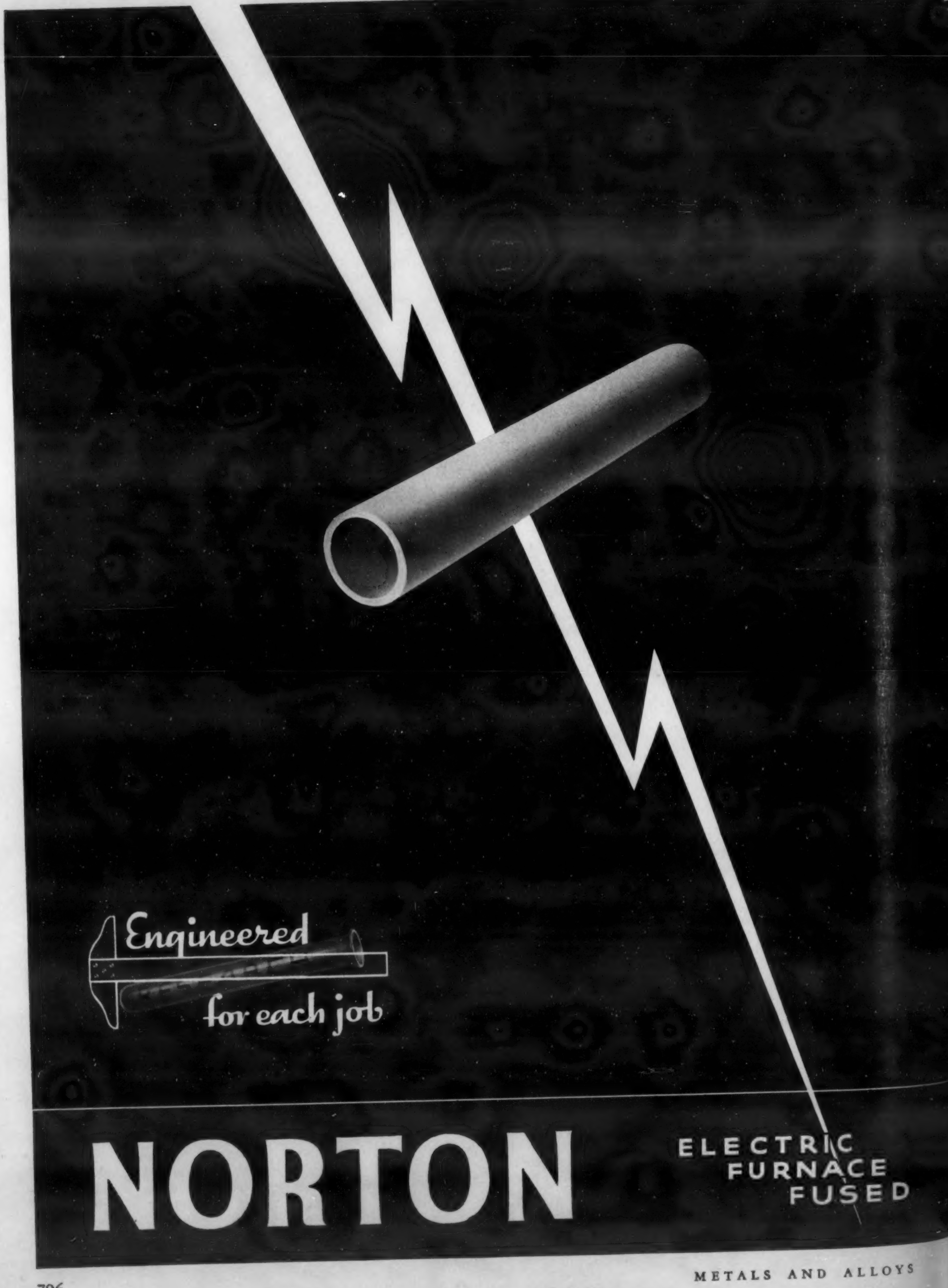
As the demands for deliveries of steel products continue to increase, so does the control of shipments. Following a telegraphic survey of steel plate consumers, C. E. Adams, Chief, Iron and Steel Branch, announced that users with excessive inventories will receive no allocations in May. A constant check upon inventories of plates is being made, because the demand continues at least 50 per cent in excess of increasing plate production which in May is expected to exceed 900,000 tons.

The new conservation order (M-126) completes the changeover of steel for use in peacetime products to exclusive use in implements of war. Patterned along the line of the Aluminum order issued last March, and the Nickel order of last May, this document will prohibit the use of carbon steels in thousands of items in several hundred categories. Long ago alloy steels were restricted for consumer use by such orders as Nickel-bearing Steel (M-5, April 10, 1942) and a series of alloy steel orders and amendments.

This steel conservation order goes a step farther, however, than its predecessors inasmuch as it will also restrict the use of a wide range of materials which might otherwise be used as substitutes. Even though its predecessors have been drastic, this order will be even tougher and widesweeping in its effects.

So far Washington has been without a complete picture of the Country's total steel production—the types of steel being produced and who is getting them. Form PD-139, which is due in Washington by the tenth of each month, is aimed at providing a means of furnishing such a picture. On it each producer must report all ton-

(Continued on page 799)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NORTON
ELECTRIC
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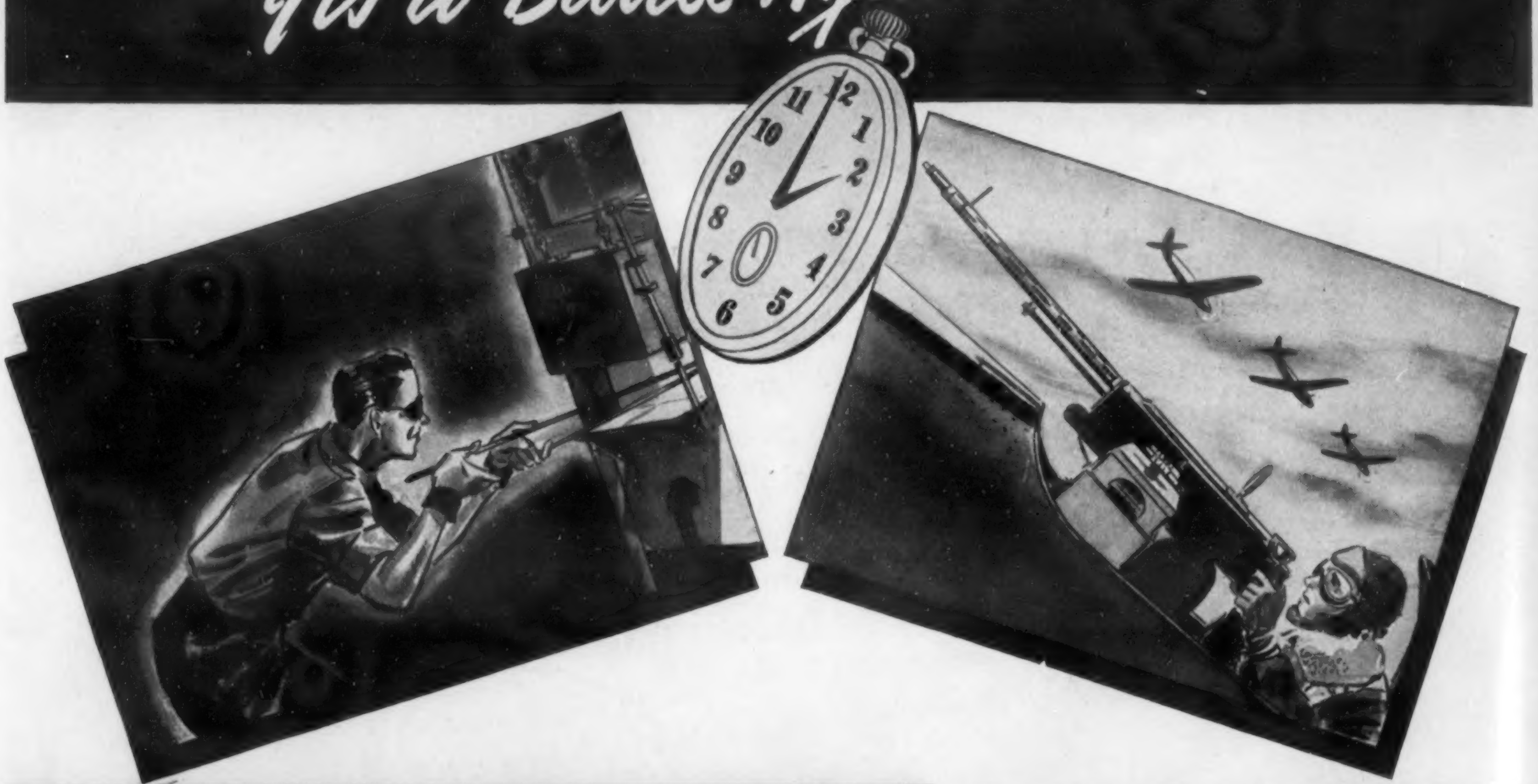
On the Production Front It's a Battle Against TIME!



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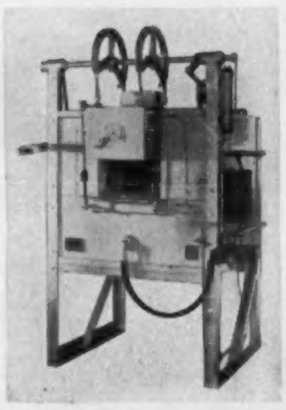
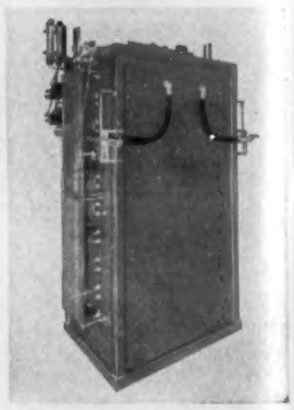
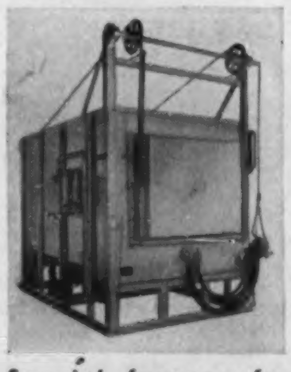
These are but mere hints of the many benefits of adequate atmospheric protection in the furnace chamber. You would EXPECT these results from furnaces that have successfully defeated the toughest atmosphere-control problems. You will EXPERIENCE these results—as so many hundreds of users are—when you put "Certain Curtain" to work in your plant! We are maintaining a good delivery schedule. Call us.



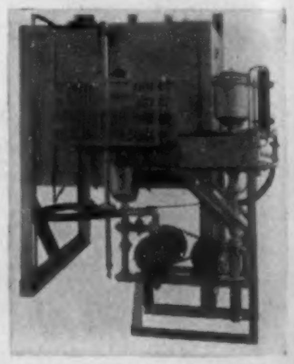
Standard furnace for hardening high speed steel tools.



Special vertical furnace for hardening large broaches up to 7 feet.



Special furnace for hardening large dies.



Special furnace for hardening MOLY STEELS without decarburization.

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Request Bulletins

World's Leading Controlled-Atmosphere Furnace

(Continued from page 795)
nages requested for delivery during that month and the following month, including past-due tonnages on the books. Information derived from this form will give the WPB, for the first time, total tonnage requested from each producer by product and by recipient.

Non-Ferrous Metals

There were many actions of importance in the non-ferrous metals field last month. William Batt, Director of Materials announced that Cuba is on its way to becoming a new source of much-needed nickel, and WPB authorized the construction of plant and facilities at a cost of $20,000,000. The job will be done by Nicaro Nickel Company, a subsidiary of the Freeport Sulphur Co.

Just about all of our supply of nickel has to be imported, mostly from Canada which accounts for around 85 per cent of the world's nickel production. No figures are available as to the exact amount of nickel being consumed at this time, but it is certain that there is a growing need of well over 10,000 tons per month to meet the demands for this vital alloying agent in the manufacture of a variety of armament products. A rapidly mounting shortage of copper last month caused WPB to make additional drastic curtailments of civilian uses of this metal.

Direct military and shipbuilding requirements and the vital needs of the United Nations is requiring practically all the copper available even though supplies of the metal have reached an all-time high. As a result civilian consumption, even in important operations, will have to be curtailed.

The program contemplates a cut of approximately 60 per cent in civilian uses from that of 1940. A large portion of the remaining 40 per cent will be devoted to vital civilian activities which really supplement military production, such as power lines, new war plants, machine tools, railroads, etc.

This program is the first in a series which will be organized by the Requirements Committee of the WPB to study and determine the total supply of scarce materials available and then figure out the best means of distributing these materials so that the most vital needs are met.

The first steps were taken early last month to untie some of the political knots which have held tight the use of silver as a substitute for some of the critically scarce metals. Donald M. Nelson announced that arrangements had been made to make available some of the Treasury's vast stores of silver for industrial purposes. Forty thousand tons have been loaned by the Treasury for use in the manufacture of bus bars many of which are used in electrolytic process plants. The United States Treasury now has more than 120,000 tons of silver on hand.

The past year has seen many new applications of silver for industrial purposes as well as increased demand for its use as a substitute for scarce metals. In 1940 only 1,250 tons of silver were consumed by industry and arts in the United States; in 1941 slightly over 2,500 tons was used, and the present consumption rate is around 4,000 tons per yr. This tremendous in-

crease in demand for silver has been brought on by war needs. The high electrical conductivity and the resistance to corrosion make silver an important material for many uses in which copper, for example, is normally used.

On the basis of last year's output, there is made available in the Western Hemisphere only about 4,200 tons of silver annually. From that figure and the present rate of demand it is obvious that all of the Western Hemisphere's output of silver can be used up in this country. If ocean shipping facilities continue to be hampered by submarine warfare and if the Treasury Department refuses to make further loans, silver too will soon be on the scarce list.

Machine Tools

Machine tools continue to be a weighty factor in the outcome of our battle with the Axis. While shipments of machine tools, presses, and other metal working machinery has increased to around 60 per cent over last year it is still not enough, and the remaining needed facilities must come from existing equipment.

A recent survey to determine present conditions in the machine-tool industry of a midwest region turned up some interesting information. The survey was conducted by the Mid-Central War Resources Board. They sent out questionnaires to 395 firms listed as being manufacturers of machinery and kindred products. The information sought included the number of workers normally employed; percentage of workers now at work; percentage of plant capacity utilized; percentage of government orders; break-down of orders between prime contracts and sub-contracts.

Perhaps the most outstanding observation from the survey was the existence of much idle machine-tool equipment. Most of the firms engaged in war work reported that they were working only one shift. Firms within defense areas had much greater success than those outside the area in obtaining subcontracts. Many of the shops in the survey were very small and of the service type. These had little experience in manufacturing a product and lacked financial backing to take government contracts. A considerable number of the machine shops, however, appeared to be capably managed and financially sound. Even with excellent modern equipment their efforts to employ their facilities in the interests of war production were unsuccessful. Perhaps increased efforts should be made to find some effective way to fit them definitely in the war-production program. *(See "Wanted: Subcontracts!" in this issue.—The Editors.)*

Another angle that might be a means of producing more machine-tools to turn out greater supplies of munitions is to simplify machinery design. Although in recent years machine-tool builders have leaned heavily towards the automatic types, there are many engineers who feel that the elimination of elaborate, automatic features and controls would save considerably in the man-hours required to build the machine-tools and at the same time, cut down on the amount and expert type of maintenance required to keep automatics in efficient running order.

McKAY ELECTRODES GIVE 'EM GUTS TO TAKE IT!

McKAY Shielded Arc-Welding Electrodes, in the skillful hands of America's welders, are performing near-miracles in production-for-war . . . SAVING as they SERVE! Saving time, man power, facilities, vital material . . . eliminating the danger of flying rivets in battle . . . joining armor plate into strong, fully integrated structures!

McKAY Electrodes are developed by practical engineers and scientists and manufactured under rigid supervision. From exhaustive research and painstaking production have come such strategically important Electrodes as McKAY Armorloy "A" and Armorloy "C"... the most advanced rods for welding armor plate yet available!

The McKay line includes regular carbon steel, stainless, and alloy steel electrodes for every welding purpose. Literature on request.

The McKay Company was among the first honored with the coveted Navy "E" award for excellence in fulfilling Naval Ordnance contracts.

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A.F.A. CONVENTION AND FOUNDRY SHOW

The 46th annual convention of the American Foundrymen's Association, in conjunction with the biennial Foundry and Allied Industries Show, was held April 20-24 in Cleveland. It was an impressive occasion, combining as it did a large industrial exposition with an imposing series of scholarly technical contributions.

[*Cleveland, according to latest reports, will in time recover. Weeks must pass before the last grain of sand is dumped out of her shoes, the last drop of core oil drained out of her pipes, and the last foundryman pried loose from Freddie's Bar, but time heals all wounds—even Cleveland's scabs, seams, rat-tails and blow-holes. Let us hope so, for as early as next October she must again be host to an equally restrained group of knowledge-seekers attending the Metal Show.—Editors.*]

Anyway (seriously), the annual gathering of American foundrymen, especially when an exposition is a feature, is always colorful, interesting and highly profitable. This year's conclave, held under all-out war conditions, was successful and profitable not only from the exhibitors' viewpoint but also from that of the average member, visitor and guest. Only a few of the highlights of this really pretentious convention can be touched on in these paragraphs.

AFA Awards

Four men received awards at the annual meeting. In recognition of important contributions to the foundry, the J. H. Whiting gold medal was awarded to A. L. Boegehold, chief metallurgist, General Motors Research Laboratory, Detroit; and the John A. Penton gold medal went to John E. Galvin, president, Ohio Steel Foundry Co., Lima, Ohio. Honorary life memberships were bestowed on Roy M. Allen, consulting metallurgist, Bloomfield, N. J. and Pat Dwyer, engineering editor, *The Foundry,* Cleveland.

The Technical Offerings

The technical sessions were of a high order, a feature being the large attendance. At most of the sessions which your editors attended there was a keen interest in the discussions, always a sign of a profitable meeting.

One of the outstanding features was a symposium on malleableizing and graphitization by the malleable fraternity. This comprised 10 papers. There were 13 papers at the various gray iron sessions; at the steel foundry meetings—some of the liveliest of the week—about 10 papers were discussed. Only 7 were scheduled at the sessions on non-ferrous foundry practice. But all these represent only a part of the technical activities—sessions on pattern making, on refractories, on core practice, on sand research as well as the gray iron and other shop courses and the lectures and round table luncheons—in all, a veritable feast of knowledge. [A few of the convention-goers, however, seemed to be more thirsty than hungry.]

Foundry Activities in South America

This year—for the first time in the history of the A.F.A.—the convention was designated as the (First) Western Hemisphere Foundry Congress. One session was devoted to this phase at which 5 papers were scheduled on foundry developments in Brazil and Mexico. Prominent among these were: "The Brazilian Foundry Industry," by H. A. Hunnicutt, Industrias Chimicas Brasileiras, Sao Paulo, Brazil; "Some Aspects of Gray Iron Founding Practice in Brazil," by Miguel Siegel, Instituto de Pesquisas Technologicas, Sao Paulo, Brazil; "A Multi-Purpose Brazilian Foundry," by Luiz Dumont Villares, Pirie Villares & Cia, Ltda., Sao Paulo, Brazil; and "Brass Founding in Mexico," by H. H. Miller, Fundicion de Bronce Miller, Torreon, Mexico.

It is not possible here to review the wealth of data presented by these authors—the papers (not preprinted) must be read to be appreciated. Your reporter was deeply impressed and quite frankly surprised at the extent of foundry operations, particularly in Brazil.

Both Mr. Siegel and Mr. Hunnicutt presented their papers in excellent English. One of these men stated that there are

Uniquely Suited TO YOUR WARTIME PRODUCTION!

Groups of Foxboro Potentiometer Controllers like these need only one motor per group. Where records are required, a single multi-pen Foxboro Potentiometer Recorder serves each group!

Foxboro Potentiometer Controllers put heat-controlling operations, too, on efficient mass-production basis

In tackling today's big-scale orders, you're just that much ahead if you can select equipment which will cut out needless duplication in procurement, operating supervision and everyday maintenance.

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What's more, simple, rugged design in these instruments not only makes their operation surer, easier . . . but practically eliminates wear and lost motion. You get *sustained* control-accuracy with minimum supervision and maintenance!

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Potentiometer Instruments

Brazilian foundrymen who gave papers at the A. F. A. Convention. Left to right—Miguel Siegel, Heraldo de Souza Mattos, Horace A. Hunnicutt.

about "400 cast iron, non-ferrous, steel and malleable iron foundries" in Brazil—about 15 per cent in the northern zone of the country, about 60 per cent in the central and about 25 per cent in the southern zone. Many of these are very small, mere repair shops for certain industries.

About 20 blast furnaces produce charcoal pig iron of varying degrees of quality and analysis. And there are a number of electric steel foundries.

An institution of decided merit in Brazil is presided over by Mr. Siegel—the *Instituto de Pesquisas Technologicas,* of Sao Paulo, Brazil. It is the official testing laboratory of the State of Sao Paulo, and it is fully provided with modern testing and other research equipment. Starting some 40 yrs. ago as a laboratory for testing materials, it is today a nationally-known institution with a large technical staff—analogous to some American consulting and research organizations. Mr. Siegel's paper was a splendid exposition of the progress in Brazilian metallurgical engineering.

Malleableizing Principles

The lead-off paper in the Malleable Division's Symposium on Graphitization was, appropriately, a review of the principles of graphitization, by H. A. Schwartz of National Malleable & Steel Casting Co. Some of the interesting points of this "correlated abstract" are as follows:

The graphitizing process involves the solution of "cementite" (iron carbide), its decomposition into its constituent elements, migration of the carbon to points where it can readily crystallize out, and the growth of graphite crystals.

Silicon, aluminum, titanium, zirconium, nickel, copper and uranium accelerate the graphitizing rate. Manganese, chromium, molybdenum, vanadium and tungsten retard graphitization.

Hydrogen, originating with moisture in the blast, hydrogen in the fuel or rust in the charge, has a considerable retarding effect on annealing. Oxygen in the iron may either accelerate or retard graphitizing, depending on its origin in the melt or annealing atmosphere.

Annealing rate varies with the gas by which the metal is surrounded while being heat treated. Annealing in hydrogen (as previously mentioned), anhydrous ammonia or acetylene is slow. The presence of *mixtures* of carbon dioxide and carbon monoxide accelerate annealing, except at high pressures below the critical point.

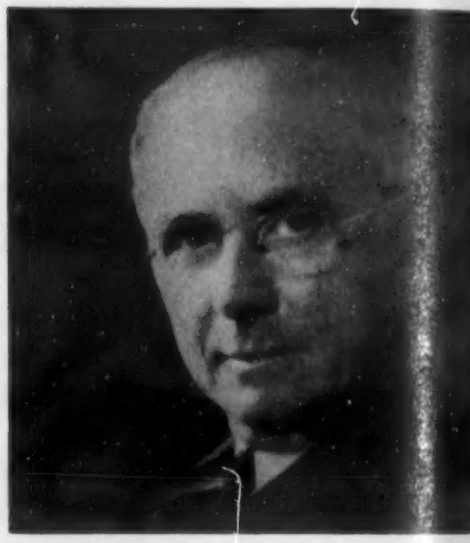
Castings annealed in an environment rela-

The J. H. Whiting Gold Medal this year went to A. L. Boegehold (at right), hard working chief metallurgist of General Motors Research Laboratory.

tively high in oxygen are commonly decarburized. If decarburization and graphitization are not too badly out of balance, the rim consists merely of a narrow band of iron that is slightly objectionable from the machining viewpoint and slightly favorable to good ductility.

No marked relation between number of graphite particles and tensile strength is evident (except in metal that has been pre-quenched before annealing, in which the nodules are small and dense and the metal is rather strong). The ductility of malleable iron increases as the size of the particle increases.

Melting factors also affect the annealing rate. This rate may depend, of course, on hydrogen and oxygen (or oxide) introduced during melting, and upon the amount of graphite in the melting furnace charge. It appears that if graphitic materials are added to liquid iron just before pouring, annealing is facilitated. Even the melting-furnace refractory is important—graphitization is easier the more acid the melting furnace lining.



John E. Galvin, president of the Ohio Steel Foundry Co., who was awarded the John A. Penton Gold Medal.

Malleable Annealing Furnaces

R. J. Cowan of Surface Combustion Corp. presented a useful discussion of the effect of furnace atmospheres on annealing, with special attention to decarburization during the high-temperature anneal as a cause of "pearlitic edges" and to its prolonging effects on subsequent anneals. This paper and several others on modern malleable annealing furnaces revealed the great strides made in this respect in recent years.

Thus, W. R. Bean & W. R. Jaeschke of Whiting Corp. reviewed the development of "periodic" malleable annealing furnaces—the direct-fired, periodic pot type, and the indirectly-fired muffle-type ovens.

R. J. Anderson of Belle City Malleable Iron Co. reported on the use of the Dressler or tunnel-type kiln for malleable annealing, with a detailed account of his company's practice and experience therewith. There are now about 9 such malleableizing kilns in use in this country, of varying designs and car capacities.

Since the original installation of the Dressler kilns they have been modified to provide either an increase or decrease in annealing capacities. Capacity increases were

Pat Dwyer, engineering editor of The Foundry, who was awarded an honorary life membership in the A. F. A.

accomplished by (1) placing additional burners at the entrance end; (2) using circulating cold air to lower the temperature of the pot at the end of the soaking zone from 1425 to 1400 deg. F. as quickly as possible; and (3) eliminating as much packing material as feasible.

To overcome the long-annealing-cycle disadvantage encountered in the use of these kilns in slow periods *(remember?)* Belle City redesigned its kiln by adding a third opening in the center of the oven, using a hinged door operated by air from the outside of the oven. This can either be swung to the "closed" position to form part of the side-wall of the normal-length kiln, or during a low-production spell, it can be used in the "open" position to serve as the exit of a half-normal-length kiln.

The advantages of electric-furnace annealing of malleable iron were cited by R. M. Cherry of General Electric Co. Heavy cast pots and packings can be eliminated, thus shortening annealing time and lowering container and handling costs. The shorter annealing time is accompanied by quicker delivery and saving in floor space. Also, heat distribution and temperature control in electric furnaces were described as ideal.

Pearlitic Malleables

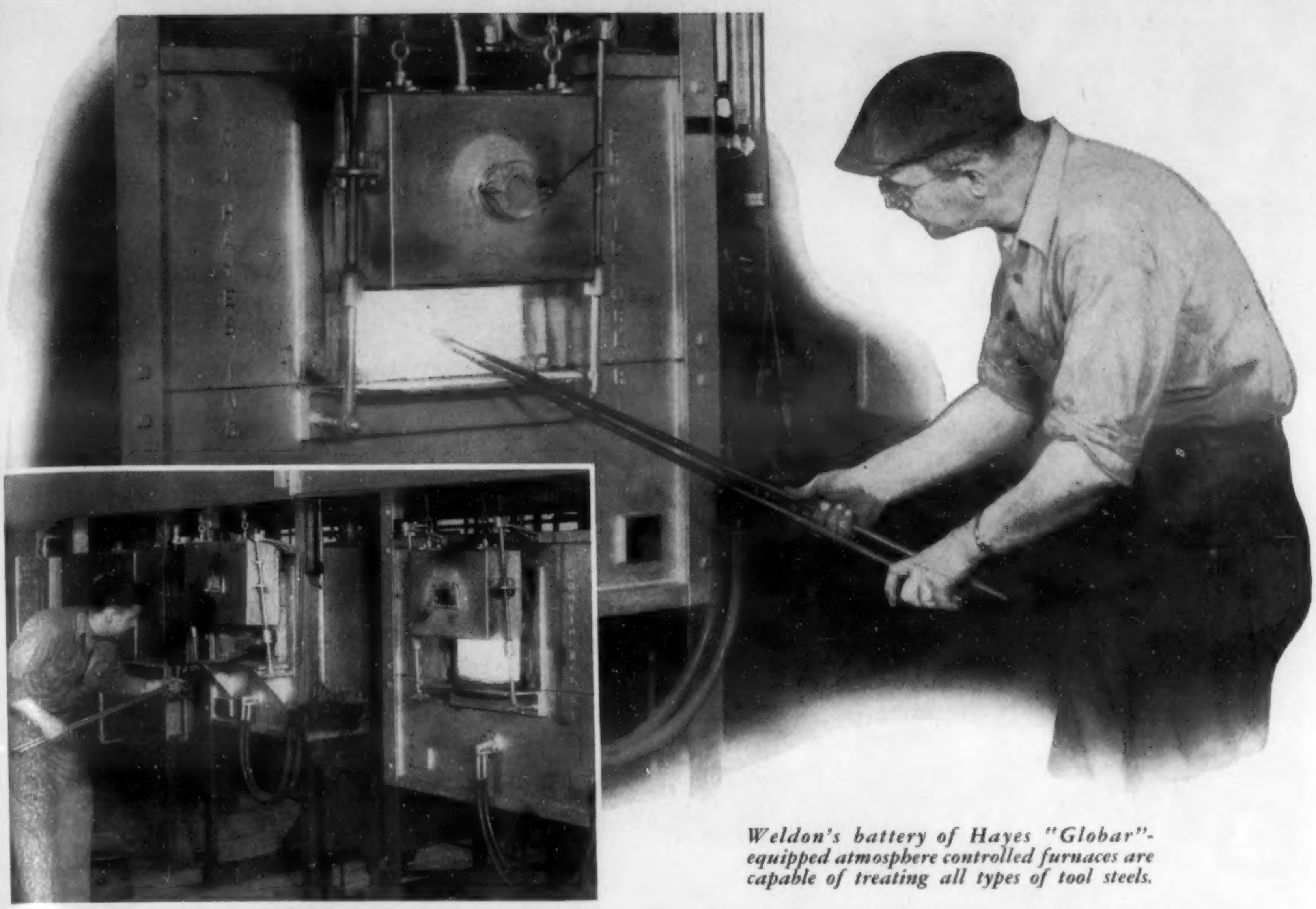
A timely discussion of "arrested anneal malleable iron" [it's still "pearlitic malleable" to us] was presented by D. P. Forbes of Gunite Foundries Corp. Two basic

Roy M. Allen, New Jersey consulting metallurgist, on whom the A. F. A. bestowed an honorary life membership.

processes used commercially to produce pearlitic malleable iron—(a) finishing the anneal with retained combined carbon by a suitable time and temperature cycle, and (b) *completely* annealing the casting so that practically no combined carbon remains in the matrix, which is then reheated above A_{cR} so that temper carbon is redissolved in the matrix and cooled or re-heat treated in such a way as to leave a desired proportion of combined carbon in the microstructure.

Under some circumstances, it is beneficial to add an alloy for the purpose of slowing up graphitization during second stage annealing. Alloy-containing irons may be

(Foundry Report Continued on Page 828)



Weldon's battery of Hayes "Globar"-equipped atmosphere controlled furnaces are capable of treating all types of tool steels.

A corner of the air conditioned heat treating department of Weldon Tool Co., Cleveland, Ohio.

WELDON TOOL CO. HARDENS "MOLY" STEEL WITHOUT DECARBURIZATION AND SOFT SKIN!

WELDON Tool Company, of Cleveland, is well known as a maker of patented double end-mills, cutters and special tools. Mr. Elmer B. Hauser, metallurgist, is pushing production to the limit these days, just as others are, but he credits his choice of furnace equipment with a large share of Weldon's ability to meet present demands and still maintain their high standards of quality in their products.

Molybdenum and other high speed steels vary widely between manufacturers, in metallurgical characteristics and physical properties. But these latest type Hayes furnaces equipped with Globar Brand Electric Heating Elements and the "Recirculator" method of atmosphere control harden them all without decarburization.

This is just another example of a plant where no compromise with quality is permitted. And where "Globar"-equipped electric furnaces make possible precision control of temperatures and atmospheres. Let us tell you how "Globar" electric heat can speed up production, increase quality and lower rejects in your plant.

Globar Division

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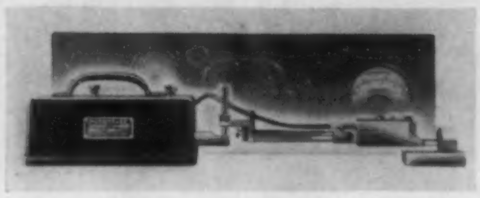
Accessory for Surface Finish Testing

A newly designed accessory to be used with the profilometer for mechanical tracing of surface finish has been announced by the *Physicists Research Co.*, Ann Arbor, Mich.

The accessory, known as a Mototrace, offers a number of new features not found in the type that was formerly manufactured. The original unit was mechanically operated by a cam and toggle acting on a rack. This method has been replaced by the use of a 9-watt driving motor, which is reversed. With this design, a length of



stroke from 1/32 in. to 2¾ in. can be obtained.

Besides a long available trace, the former "dead spot" from ⅛ in. to ⅜ in. is eliminated, thereby allowing continuously adjustable setting. Provisions have been made so that, if the motor should become locked, it does not heat up and the motor is not damaged.

The Mototrace is especially valuable for securing accurate readings on very fine surfaces. By its use, the profilometer tracer is drawn without vibration across the piece being measured. It is also useful for measuring softer materials, awkward shapes, distances as short as 1/32 in. and surfaces such as those in small holes, adjacent to shoulders or bosses, and on gear and hob teeth.

Temperature Indicating Paints

A method enabling a permanent and definite indication of the temperature reached on a heated surface by means of a sharp, clear-cut change of color has been developed by *J. M. Steel & Co., Ltd.*, London, England. The method involves the use of a paint, known as Thermindex Colours, applied directly to the surface of the metal being heated.

The paint can be applied to the surface by brushing or spraying and drys quickly at room temperature. When the temperature of the heated surface is raised, the original color of the pigment changes sharply at a definite point, and the new color persists after the surface has cooled down. A range of Thermindex Colours covering many temperatures is available.

While the change of color is dependent mainly on the temperature attained, the length of time to which the color is exposed to that temperature also has some effect. The paint has been standardized on an exposure period of 10 min.

This method of temperature measurement has many uses in the metal industries. The use of these colors in research work will give what is in effect a picture of temperature distribution over a heated surface, instead of the temperature at any specific point obtained with the more usual measuring devices.

Their most important application, however, is in actual production, where they can be used on metal subjected to heat treatment or for which pre-heating is necessary. In heat treatment processes they give, by a simple change of color, visual indication that the object has, in fact, been subjected to treatment and, in addition, that a certain minimum temperature has been attained. In the pre-heating of metal for welding, they can be used to show that the minimum temperature necessary has been attained.

Dust Collectors

A new line of self-contained dust collector units in 3 sizes has just been announced by *Hammond Machinery Builders, Inc.*, Kalamazoo, Mich. The 3 sizes are reported to be of a new, compact, functional design, thus requiring a minimum of floor space.

These units have a multitude of applications with various types of grinders in plants that do not have central exhaust systems, and in plants whose central exhaust system is not available to numerous isolated grinders.

Bombs by "Spinning"

National Tube Co., Pittsburgh, recently announced that bomb production by a new spinning method has been developed and perfected at one of the company's plants and has reached the point of efficiency where the process can be utilized at other plants for turning out increasing quantities of this vital American war weapon.

As a result, production of bombs by this method for the Army and Navy will be greatly increased. The process is being utilized by the Army Ordnance Department, which plans to install similar machines in plants of other manufacturers. National Tube Co. is lending its aid in educating these potential producers by giving them the benefit of experience gained from nearly 20 months of actual production.

Bomb production by the spinning method is said to be speedy and effective. The process involves the use of a pre-heated steel tube, turned at a high rate of speed, and fashioned quickly and with surprising precision, into the nose and main body of a bomb by a huge arm, which swings into position and molds the revolving tube into the desired shape. Other machines, by the same method, shape the tail portion of the main bomb body.

Bombs of various sizes are made by this method. After they leave the spinning machines they are normalized, finished, threaded, and have carrying lugs welded on. Then they are painted and shipped to loading plants as the first leg on their journey toward action.

Oil Hydraulic Press

A new, highly versatile oil hydraulic press, offered in capacities of 50 tons and up, has been announced by *Denison Engineering Co.,* Columbus, Ohio. It supplements the applications and wide range of tonnage capacities previously offered by this company's line of small capacity presses. It is adapted to a wide range of straightening, assembling and pressing operations in either small-lot or production work.

This press is reported to be of rugged construction, self-contained, free of projections, and safer to operate. The safety factor has also been considered in the location of controls, and the press ram is threaded internally for attaching, assembling or straightening tools.

General arrangement of the press is as follows: the ram and cylinder head assembly is located in the top part of the box frame; the directional control valve and its operating mechanism, motor, pumps, tonnage controls, and oil reservoir are located in the base of the press.

● Development by its research laboratories of a superior type of hard rubber made from Ameripol, the synthetic rubber which its chemists created, is announced by *B. F. Goodrich Co.,* Akron, Ohio. According to a report just issued, the new synthetic hard rubber will stand temperatures 100 deg. F. higher before softening than the best hard rubber made from natural crude.

Filter Fan for Dust Control

Claude B. Schneible Co., Chicago, are marketing a newly designed collector unit to remove dust and fly ash from flues, kilns and furnaces, smelter stacks and cupolas. The collector consists of a combination housing on which is mounted a rejector wheel and fan wheel. These two wheels are on a single motor-driven shaft.

Solids are removed from the gas stream by means of this rejector wheel, which throws the particles into a dead zone and hopper by centrifugal force. The dust particles do not come into contact with the wheel, thus eliminating wear on the wheel blades.

For high temperature stack gas, the dust collector is equipped with a hollow water-cooled shaft with packing glands and water connections provided at both ends. If desired, jets are placed in the refuser wheel housing. Water from these jets floods a portion of the scroll and hopper, thus protecting against abrasion and insuring dustless removal of the solids.

You Can Help War Production By Using Ferro-Alloys Efficiently

ALTHOUGH certain alloys are difficult to get these days, the selective use of available alloys should permit you to produce steels and irons of the desired properties without materially changing your practice. You may substitute available standard grades of alloys for the special grades formerly used. You may use different combinations of deoxidizers and get the same result. Or you may change the composition of your iron or steel to use available alloys, and still get the good physical properties required.

Our metallurgists can give you practical on-the-job assistance in the best use of alternate alloys. Perhaps they can suggest how you can overcome a supply problem, or how you can change your practice and still make a quality product. This service is backed by more than 35 years' experience in the production and use of high-grade ferro-alloys. If you have a problem in the use of ferro-alloys, consult us. There is no obligation.

ELECTRO METALLURGICAL COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York, N. Y.

Items of Interest about "Electromet" Ferro-Alloys

•

Zirconium Improves Machinability of Steel Castings – Zirconium in steel castings retards segregation of impurities at the grain boundaries, eliminates hard spots, reduces grain size, and produces a cleaner and more uniform steel. As a result, machinability is greatly improved, which saves time and speeds production.

Medium-Carbon Ferromanganese Speeds Production of Low-Carbon Steels – In the production of low-carbon steels, medium-carbon ferromanganese adds only about one-sixth as much carbon as the standard grade. Hence less oxidation of the bath is required to lower the carbon content. Furnace time is materially shortened. Refractory maintenance is decreased. The amount

of deoxidation required is less. As a result, more steel is produced at lower cost and in less time.

Silico-Manganese Simplifies Production of Low-Carbon Manganese Steel – Silico-manganese is a quick and effective deoxidizer for both acid and basic open hearth steel. The low carbon content of this alloy, coupled with its rapid cleansing action, simplifies the making of low-carbon manganese steel and facilitates close control of final carbon content.

For Cleaner Steel, Make a Final Addition of Calcium-Manganese-Silicon – Calcium-manganese-silicon, used as a final alloy addition to steel, produces a cleaner, coarse-grained steel with deep-hardening properties. Long commercial use of this combination alloy has proved its merits for this purpose. Calcium-manganese-silicon is also being successfully used to deoxidize all types of stainless steel, high-speed tool steels, and special steels subject to transverse testing.

Write for This Booklet

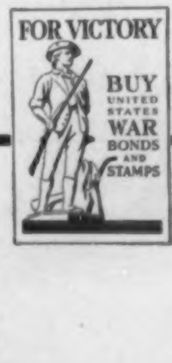
If you want more information about "Electromet" ferro-alloys and metals, their use, and the service that goes with their purchase, write for this 24-page booklet entitled "Electromet Products and Service."

Electromet

Trade-Mark

Ferro-Alloys & Metals

Distributed through offices of Electro Metallurgical Sales Corporation in Birmingham, Chicago, Cleveland, Detroit, New York, Pittsburgh, and San Francisco. In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario.



Welding Rod to Conserve Nickel

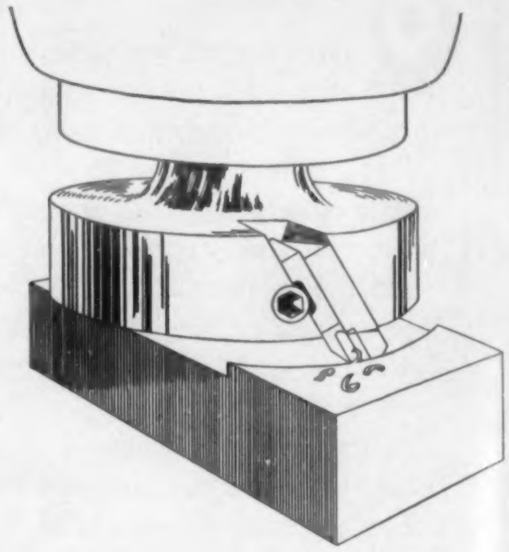
To conserve nickel for our war effort, so that it can be used where it will do the most good, the *American Manganese Steel Div., American Brake Shoe & Foundry Co.,* Chicago Heights, Ill., now has available a new manganese steel welding rod known as V-Mang.

An alloy steel containing 12-14 per cent Mn, molybedenum and other elements, this electrode has resulted from research started several years back. It will replace Amsco nickel-manganese steel electrodes, except in a few exceptional cases, thus conserving this critical metal without hampering reclamation of manganese steel and other ferrous equipment parts, so necessary at this time.

Thorough tests under field conditions have shown that the new rod can be applied as readily as nickel-manganese steel rod, and that it has ductility and tensile strength equal to or better than nickel-manganese steel rod as applied. The new rod can be used to repair fractures in manganese steel parts, as well as for build-up work, and to deposit a uniform bead similar to that afforded by nickel-manganese electrodes.

Milling Cutters

McKenna Metals Co., Latrobe, Pa., announces a method by which simple facing cutter heads may be made in almost any shop. Due to its high speed of cutting, this single-bladed cutter will often work



more efficiently than a standard cutter requiring many high-speed steel blades.

Designed with a large negative spiral angle of 35° to 55° and positive hook of 15° to 24°, this cutter mills steel efficiently only because Kennametal tools do not "gall" or permit the adherance of steel chips to the hard, strong, non-galling tool tip which "skids" the steel chip off smoothly at these angles.

The cutters should be run to give 500-600 ft. per min. peripheral speed, with a table feed of .008 in. per revolution, depending on the material being machined. A 6 in. diam. head gives about 3 in. per min. table feed at 380 r.p.m. (600 ft. per min. cutting speed). Clearances should be kept to a minimum and only a slight radius used. No coolant should be used, as it is impossible to keep the cutting point flooded at the speeds employed.

Conservation Through Fin-Tube Heat Exchangers

Development of fin-tubes in heat exchanger equipment saves an appreciable amount of the metals originally required for tube construction, according to the *Alco Products Div., American Locomotive Co.,* New York. The estimated savings effected by this type of equipment in many cases may be as much as 40 per cent.

The use of fin-tubes where applicable in the place of bare tubes (the more conventional type) in heat exchangers makes a saving of from 65 to 75 per cent in the number of tubes required, it was stated.

Oil exchangers containing the fin-tube construction are being used importantly in U. S. Navy shore bases and on U. S. destroyers, cruisers and other warships, as well as in the oil industry throughout the country.

Electrodes for Armor Plate Welding

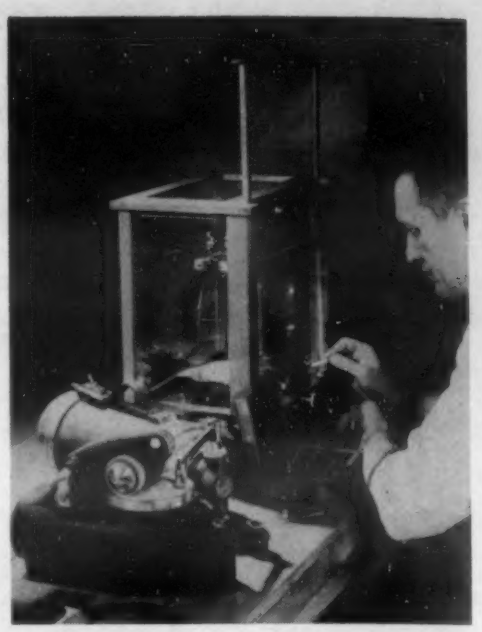
Three electrodes now being manufactured by the *Harnischfeger Corp.*, Milwaukee, Wis., have been developed specifically for the welding of armored vehicles according to Army Ordnance Dept. specifications.

Harnischfeger engineers worked in co-operation with Government technicians on the development of these armor plate welding classifications and procedures from the very start. Details of the new electrodes and their application pertaining to armor welding are restricted to prime- and sub-contractors qualifying under Ordnance regulations.

Accessory for Abrasion Resistance Measuring Machine

The Taber Instrument Corp., North Tonawanda, N. Y., has announced its improved abraser vacuum pickup, an accessory to the Taber abraser used for measuring resistance to abrasion of surface finishes. The primary function of the accessory is to prevent accumulation of abradings from interfering with the normal wear action of the abrasion measuring wheels.

The vacuum pickup accessory is of tubular design for standing on the table alongside the abraser, and has a nozzle rotatively mounted on the suction end of the



housing so as to swing in and out of position relative to the specimen holder.

The nozzle holder can also be adjusted vertically to the proper height above the specimen by turning the knurled collar located on the stem. The contaminated air is drawn through the nozzle and connecting tube into the high-speed centrifugal pump, then through a special filter bag which passes only clean air back into the room.

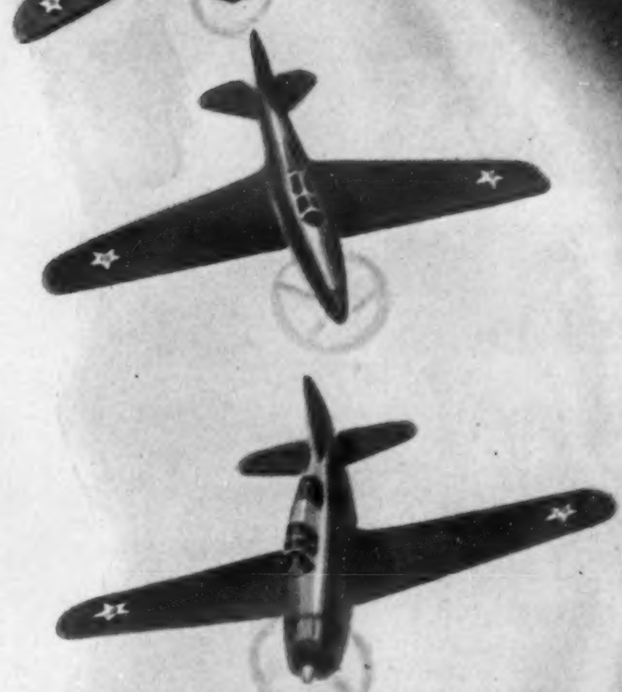
Strength of Brazed Joints

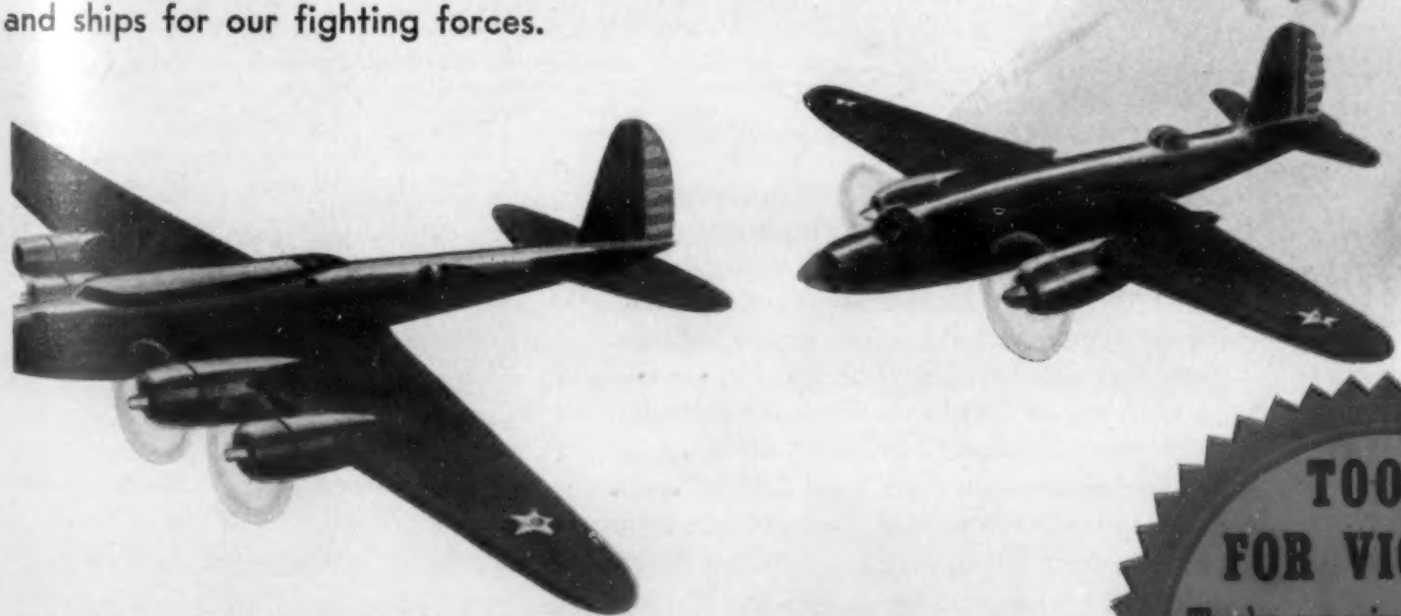
Tests by *Handy & Harman*, New York, now directing the American Silver Producers' Research Project, have proved that joints brazed with silver alloys are readily made stronger than the metals brazed. This is not always true of ordinary butt joints, but can be made true of lap and scarfed joints, providing the length of lap or scarf is made adequate. Even butt joints produced by brazing stainless steel to stainless steel with a silver alloy, when properly made, have been found to yield a tensile strength as high as 134,000 lbs. per sq. in.

The design, and especially the area of the joint, is probably the most important factor controlling its strength, but it is far from being the only factor. Other factors include the kinds of metal joined, the clearances between parts and, in some cases, the skill of the operator who does the brazing. All these factors can be controlled within reasonable limits.

Research has shown that, under most conditions, a joint has maximum strength when clearances into which the silver alloy is flowed are approximately 0.0015 in., but in tests using stainless steel and a silver brazing alloy as indicated above, any properly made joint under 0.005 in. clearance was found to have at least 100,000 lbs. per sq. in. tensile strength.

With many metals even a butt joint is stronger than the metals brazed, so that the break in a test specimen usually occurs, not in the joint, but outside it, making the precise strength of the joint difficult to determine.





Slants and Plants

It was announced by the *United States Steel Corp.*, Pittsburgh, that the subsidiary companies of the Corporation in March established all-time records in producing nearly 2,000,00 tons of blast furnace products and almost 2,600,000 tons of steel ingots and castings.

Orders amounting to around $300,000,000 have been booked since the first of the year by the *Westinghouse Electric & Mfg. Co.*, East Pittsburgh. Substantially all the work is directly or indirectly for the Army, Navy, Maritime Commission or other government agencies.

Chamberlain Engineering, Ltd., a unit of *United States Stoneware Co.*, Akron, Ohio, has acquired 6 additional buildings. When the additions are completed, the facilities will be ample for the handling and lining of full sized tank cars and for any size of steel plate construction that can be transported on railroad flat cars.

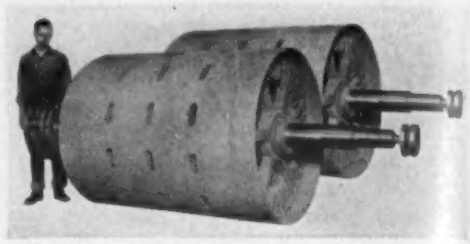
In order to provide facilities for the greatly increased volume of research and experimental work necessary under present conditions, the plating laboratories of the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J., have been completely reconditioned and expanded.

Because of the need of putting all tools into immediate production, there will be no Machine & Tool Progress Exhibition in 1943, according to the decision made at the annual meeting of the *American Society of Tool Engineers*.

It was reported recently by M. M. Boring of *General Electric Co.* that jobs for engineering graduates last year were the most plentiful in 20 years, and this year they are twice as numerous. It is estimated that there is a shortage of 82,000 technical graduates this year.

To increase its salvaging capacity, *Allegheny Ludlum Steel Corp.*, Pittsburgh, is building a new reclamation plant, which will concentrate on the processing of low-alloy steels to save the alloy content.

Stearns Magnetic Mfg. Co., Milwaukee, has recently shipped two of the largest magnetic pulleys ever built. They have



been installed in a huge copper mining and reduction plant. The pulleys weigh about 20,000 lbs. each.

Completion of a substantial expansion in bomber production facilities was announced recently by *Fisher Body Div., General Motors Corp.*, Detroit. Production in April was several times greater than that for any previous month. At about the same time *General Motors* announced a three-point program to help keep the planes, tanks and guns at highest possible fighting efficiency. The program includes training mechanics by maintaining schools for Army and Navy instructors, placing its own engineers in the field to expedite reports on operating experience, and assist the Army and Navy in having replacement parts on the spot when needed.

Active mining of domestic bauxite has been commenced by a subsidiary of *Reynolds Metals Co.*, in Arkansas. Original shipments of bauxite for the Reynolds' plant came from the Netherlands East Indies.

The Tennessee Coal, Iron & Railroad Co., subsidiary of the U. S. Steel Corp., has awarded a contract to *Koppers Co.* for the design and erection of 73 Koppers-Becker coke ovens at Fairfield, Ala.

● It has been proposed, according to *Charles Hardy, Inc.*, New York, to produce very fine powders of metals from their super-heated vapors by feeding individual drops of the metal onto a smooth, refractory, heat radiating surface in a hot closed chamber so that substantially the entire surface of the metal is subjected to heat by radiation, with resultant production by metal vapor, which is discharged and condensed.

No. 35 OF A SERIES of Typical Installations

STEWART

THE BEST INDUSTRIAL FURNACES MADE

NEW 75-UNIT STEWART INSTALLATION AT THE MACHINE AND METAL TRADES HIGH SCHOOL, NEW YORK

Typical of the Stewart furnaces that are providing the basic vocational training so much in demand by war industries

Large illustration shows 4 Stewart Triple-combination furnaces, 12 Stewart Bench Oven furnaces, 1 Stewart double-deck high speed steel pre-heat and high-heat furnace, 2 Stewart semi-muffle oven type furnaces, 3 Stewart direct-fired forge furnaces. Small illustration at right shows 6 Stewart semi-muffle oven furnaces with other standard Stewart units in background.

With the metalworking industries all-out in their war production effort, the need for men with practical training in heat treating is now more acute than ever.

Literally thousands of standard Stewart furnaces are in the Vocational departments of technical schools and colleges. Because these Stewart units have been designed for efficient production heat treating in small shops and tool rooms, they are recognized as standard equipment for all types of industrial heat treating and vocational training work.

The 75-unit Stewart installation at the Machine and Metal Trades High School, New York, is one of the newest and largest of its kind in the U. S. There are furnaces for carbon-steel, high speed steel, cyanide, lead hardening and tempering work, forging and bending, brazing, metal melting, tool room and general production heat treating, as well as experimental work of all kinds.

In addition to the famous line of standard furnaces, Stewart engineers design and build oil or gas-fired heavy duty furnaces, car, pusher or conveyor types, plate heating, shape and angle heating, shell nosing, shell and shot heat treating, and rotary hearth shell forging furnaces.

A letter, wire or 'phone call will promptly bring you information and details on standard or special Stewart furnaces suitable for your requirements. Or if you prefer, a Stewart engineer will be glad to call and discuss your heat treating problems with you.

STEWART INDUSTRIAL FURNACE DIVISION of CHICAGO FLEXIBLE SHAFT CO.

MAIN OFFICE: 5600 W. Roosevelt Rd. Chicago, Ill.

CANADA FACTORY: (FLEXIBLE SHAFT CO. LTD.) 321 Weston Rd., So. Toronto

FROM A 25 TON CAR-TYPE ... TO A 6 INCH POT

Treating Stainless Steel By a New Process

Quantities of nitric acid, vital ingredient of high explosives, may be released for war use if a new process of treating stainless steel proves commercially successful, according to Dr. Herbert H. Uhlig, of the *General Electric Research Laboratory,* Schenectady, N. Y.

Stainless steel, which consists of 18 per cent Cr, 8 Ni and balance iron, has many military as well as civilian applications. Both to improve its appearance and give it greater resistance to corrosion, it is usually treated with nitric acid, to which a little hydrofluoric acid has been added. This gives it a silvery instead of a grayish color.

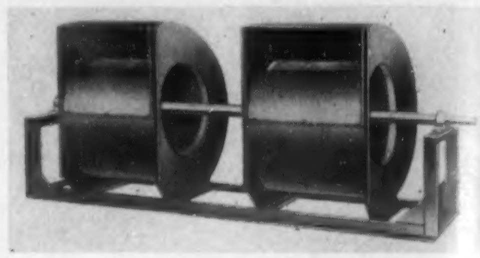
The metal surface consists of microscopic peaks and valleys, and the effect of the acid is to eat away the peaks, while only slightly affecting the valleys, making the surface smoother. Hydrochloric acid, by itself, will produce a different effect, it was stated, for it attacks both peaks and valleys, and the appearance and corrosion resistance are not improved.

However, it was found that by adding a chemical inhibitor to the hydrochloric acid, the valleys are protected, and this produces on the stainless steel a surface equal to that of nitric acid.

Since nitric acid is used now in enormous amounts to add necessary nitrogen to cellulose and other compounds in the manufacture of high explosives for shells and aerial bombs, the hydrochloric acid treatment for stainless steel may help prevent any shortage in the explosives industry.

Motor Blower Units

Production of motor blower units in a wide range of sizes for a variety of industrial applications is announced by the *Niagara Blower Co.,* New York City. The new blower units are applicable to industrial and commercial ventilating, drying, heating, cooling, exhausting, processing and air conditioning requirements, and are available in 16 models.



The blowers may be secured with or without castings. They are belt-driven or direct connected, and are especially designed for simplified application to duct systems. Because of the wide variety in types of blowers, a proper selection may be made for successful operation of all industrial and commercial applications.

Blackening Copper and Copper Alloys

The Enthone Co., New Haven, Conn. has just announced the development of a new process for direct, low temperature, chemical blackening of copper and copper alloys. The process involves immersion in a solution of blackening salts operated near the boiling point or from 200 deg. to 212 deg. F., and the blackening is accomplished in from 2 to 10 min., depending upon the alloy being blackened.

The process is stated to be suitable for blackening copper, beryllium copper, bronze, phosphor bronze, and brasses with zinc contents of 35 per cent or less. High brasses are colored a chocolate brown. The coating produced is, according to the manufacturer, unique in its properties. The coating is essentially cupric oxide, and being integral with the base metal, it cannot chip or flake. In addition to being jet black, the coating is hard enough to be buffed and does not have to be lacquered to prevent wear.

Non-copper alloys capable of being copper plated can be readily blackened by first copper plating and then blackening the copper. Inasmuch as no electric current is involved in the blackening process, small parts can be blackened in baskets, or in horizontal or oblique barrels, and large parts, of course, are blackened on racks or hooks, or stacked in baskets.

Watt-hour Meter For Controlling Electroplating Current

A new use for the ordinary watt-hour meter is to provide an accurate and refined control of the current used in electroplating permanent magnets at the *Westinghouse Electric & Mfg. Co.* Newark works. The cost of the unit is less than that of the amp.-hr. meter commonly used and, in addition, expensive and cumbersome shunts across the plating electrodes are eliminated.

The watt-hour meter is connected to the alternating current side of a rectifier such as is used to supply direct current for electroplating. The register for the watt-hour meter includes a switch device adapted for closure after a predetermined amount of energy passed through the meter. This switch operates a circuit breaker to open the energizing current circuit and thereby interrupts the plating or charging circuit when the desired plating thickness is attained.

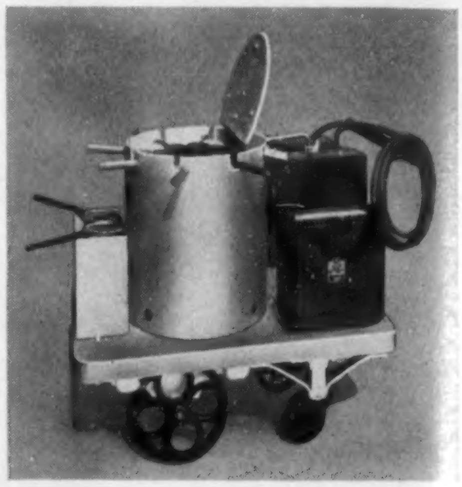
Since the voltage of the alternating current is substantially constant, the number of amp.-hrs. of the output rectifier will be proportional to the energy consumed, and no special amp.-hr. meter or timing device is necessary to obtain accurate electroplating results.

The watt-hour meter may be placed on a switchboard some distance away from the plating tank, whereas in the case of the amp.-hr. switch it is necessary to place the shunt near the plating tank in the heavy output lead. This means that, besides taking up valuable space used by the shunt, extra precaution must be taken to protect it and the leads from the plating solution and fumes from the parts being plated.

Portable Electric Salt Bath

Charles F. Kenworthy, Inc., Waterbury, Conn., has announced a new electric salt bath furnace for use in a variety of heat treating operations.

The accompanying photograph shows the



furnace with a complete pyrometric controller, ladles, quenching baskets and electric plug-in cable.

Electrolytic Tinning Process

Both tin and electric power will be conserved by a faster, more economical electrolytic process for plating strip steel with tin, according to the *Electroplating Div. of E. I. du Pont de Nemours & Co.*, Wilmington, Del. Known as the Halogen tin process, this process employs a neutral solution which is said to eliminate sludging and the consequent waste of tin common to many electrotinning methods.

It is claimed that strip steel for containers can be tin-plated twice as fast with less electric power by this process as by the "alkaline" electrotinning method, thereby reducing substantially labor and power costs. At the same time, a thinner, more uniform coat of tin can be applied to strip steel electrolytically rather than by the conventional "hot dip" method, and is said to result in savings of from 40 to 65 per cent of the tin used.

Tin deposited by the Halogen process can be heated without discoloration, either when tin-plate is heated to obtain the bright finish required by some can manufacturers or when treated during the process of applying lacquers or enamels.

WHERE SHOULD HEAT TREATING HEAT GO?

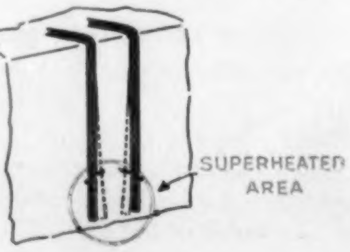
Comments on Salt Baths of Vital Importance to Anyone Doing Heat Treating

THE VERY OBVIOUS answer to "Where should the heat go?" is that it should go into the work as rapidly and as uniformly as possible and without causing superheating.

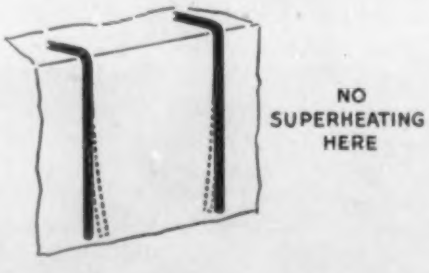
To accomplish this the heat must first be generated within the pot in such a manner as to insure the best distribution—no matter what kind of work is placed in the pot. Moreover, most of the heat should remain in the pot until it is removed as an integral part of the work itself.

Concentrated hot spots must be avoided—otherwise cracking of large pieces being treated at high temperatures is liable to result. At lower temperatures, superheated areas will swiftly decompose salts and a carburizing bath cannot do its work if it is "out of balance."

The highest heat treating speeds possible are accomplished with liquid baths. The internally heated salt baths are usually considered "tops" in speed. These baths are heated by placing electrodes in the salt itself, heating being accomplished by the resistance of the salt to the passage of the current. If the electrodes are placed close together there is a good chance that the high heat will warp them into contact with each other or even approaching each other to cause super-heating. The dotted lines in this sketch show how heat-warped



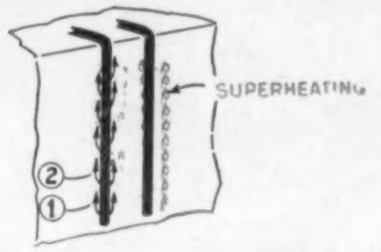
electrodes can ruin an otherwise perfect salt bath balance. By selecting a furnace with the electrodes placed as in this sketch,



extreme warpage (dotted lines) could not induce the superheating. Rule number 1 should be to look for a furnace with plenty of distance (in feet rather than inches) between electrodes.

No matter where heat *should* go, it will always tend to rise vertically. This is true, of course, for any heated gas or liquid. It is possible, by the use of physical force, to make the heated substance go in *any* direction for a short distance, but when the force that turns it from its natural direction ceases, the heat immediately turns upward.

If the electrodes in the salt bath are placed vertically, this is what happens: the heated salt (at 1) that surrounds the bottom of the electrodes rises. As it starts up, it encounters salt that is heated at, say, point 2. These two join forces, so to



speak, by combining their respective heat and a superheating immediately starts. This progressive heating continues upward along the entire length of the electrode. It is easy to imagine the temperature that exists in the salt before it even gets to the surface.

When electrodes are placed like this,

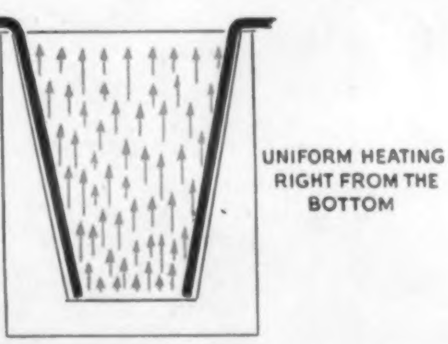
the heated salt rising from any one point does not co-mingle and add its heat to salt rising from farther on up the electrode. Thus, progressive heating cannot affect the salt balance. Rule 2: Get pots with sloping walls.

Since the motion of the heated salt is directly upward from the electrode, it is replaced by cooler salt from the bottom of the pot. The resultant circulation action is rapid, complete and uniform with the salt moving down the vertical wall toward the bottom of the pot for reheating This natural, unforced circulation has proven especially valuable on large size

work and on small work where rapid uniform heating at high speed is required.

Saw blades present an interesting problem in heat treating and illustrate why electrodes are placed at diagonal corners. Saw blades are long, they must be heated uniformly and rapidly. All the salt in the extremely deep pot they require must be uniformly heated. This means that heat must be supplied at or near the bottom.

To get the most heat there, electrodes are placed in diagonally opposite corners of the pot with their ends converging at the bottom. The greatest current flow is at the bottom of the pot. Consequently, the greatest amount of heat is generated there to flow upwards, intermingling and lending its heat to the work suspended in



the pot. Rule 3: be sure heat is generated *normally* at the bottom of the pot.

Even in high temperature work, where superheating is not as important a danger as it is in the carburizing baths, there is no concentration of heat. The electricity heating the salt spreads the heat over the entire area of the pot. This is the basis, in part, of the ELECTROTHERMIC-PERMEATION principle of operation.

News of Metallurgical Engineers

J. Eugene Jackson, until recently metallurgical engineer with the Copper Iron & Steel Development Association, has accepted a position as senior industrial analyst with the War Production Board. . . . *John Marsh,* formerly editor of "Alloys of Iron Research," published by the Engineering Foundation, is now on the technical staff of the Bethlehem Steel Co.

Otto W. Winter, vice-president in charge of manufacturing, Republic Drill & Tool Co., was elected president of the American Society of Tool Engineers at the annual convention of the society. . . . *Charles M. Craighead* has been named a research metallurgist on the staff of Battelle Memorial Institute. He was formerly associated with the Aluminum Company of America, the Reynolds Metals Co. and the Braeburn Alloy Steel Corp. . . . *Horace J. Grover* has also been added to the Battelle staff as a research physicist.

The Franklin Medal and a Certificate of Honorary Membership, the highest honors that can be bestowed by the Franklin Institute of Philadelphia, will be awarded to *Dr. Paul Dyer Merica,* vice-president and director of the International Nickel Company of Canada.

Gordon McMillin has resigned his position as metallurgist for the Standard Brake Shoe & Foundry Co., and is now metallurgist for General Steel Castings Corp. . . . *Dr. Maurice C. Fetzer,* formerly Assistant Professor of Metallurgy at Pennsylvania State College, has joined the staff of the Carpenter Steel Co. as a research metallurgist.

R. W. Aiken has been named plant engineer of the Jessop Steel Co. He was previously chief engineer with Frazier-Simplex Inc. . . . *Ray C. Sackett* has joined the headquarters staff of the Society of Automotive Engineers to assist in the S.A.E. war program.

Four personnel changes in the metallurgical and research departments have been made by the American Steel & Wire Co.: *John S. Richards* has been appointed director of research, and will be succeeded as manager of the metallurgical department by *James R. Thompson; Flint C. Elder* has been named research engineer; and *Lawrence H. Dunham* has been made assistant manager of the metallurgical departments.

● As an alternative to aluminum paint priming, *Midland Paint & Varnish Co.,* Cleveland, offers a metal lead primer which, because of its metallic, non-rusting components, is claimed to be equal in its protective value to that of a good grade of aluminum paint. It is said that this paint will not crack or flake off, holds tight to metal under rapid climatic changes, and is also highly resistant to the salt impregnated air of the seaboards.

Meetings and Expositions

AMERICAN PETROLEUM INSTITUTE, mid-year meeting. Oklahoma City, Okla. May 25-28, 1942.

SOCIETY OF AUTOMOTIVE ENGINEERS, semi-annual meeting. White Sulphur Springs, W. Va. May 31-June 5, 1942.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. Cleveland, Ohio. June 8-10, 1942.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, summer meeting. St. Paul, Minn. June 15-17, 1942.

EASTERN PHOTOELASTICITY CONFERENCE, semi-annual meeting. Boston, Mass. June 20, 1942.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer convention. Chicago, Ill. June 22-26, 1942.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Atlantic City, N. J. June 22-26, 1942.

Colloidal Graphite for Precision Assembling

Precision assembly operations, always presenting difficulties even under normal conditions, now are faced with additional problems in endeavoring to meet the tremendous demands of the war effort. This is proving especially true where a large amount of time is required for careful checking and re-checking of dimensions when limits and fits are extremely close.

Where hand scraping or touching-up surfaces by lapping or special grinding, or where any of the other old time methods must be applied, such as repeated tedious selection in the mating of one part with another, similar problems prevail.

It is reported by *Acheson Colloids Corp.*, Port Huron, Mich., that one of the methods now being used by some companies to save time and often materially reduce operations of this kind is in the use of colloidal graphite for coating the mating surfaces prior to fitting or assembly.

A specific example is in its use in assembling and breaking-in of airplane engines. Many aircraft engine parts have to be manufactured to extremely close limits. These parts are then usually sorted according to variations in size—in steps of a few ten-thousandths of an in. This is followed by selective assembly to similarly close tolerances for the fits of mating parts. In such cases, parts that might otherwise gall from metal-to-metal contact during their initial operation in test or service are now being assembled with mineral oil carrying a colloidal graphite dispersion. This procedure reduces the possibility of abrading the surfaces when fits are extremely close.

The fine graphite particle size used in colloidal dispersions in mineral and other oils has proved its direct value in assembly operations of this kind, partly due to its ability to adhere to the metal under normal pressures and thus provide a dry-lubricating graphite film protecting the parts even when oil lubrication becomes scanty. Also, its characteristic of becoming absorbed onto the surface of the metal and forming a graphoid surface is of value. Metal-to-metal contact in the ordinary sense does not occur as readily, and the parts are better protected from galling.

Corrosion Problems

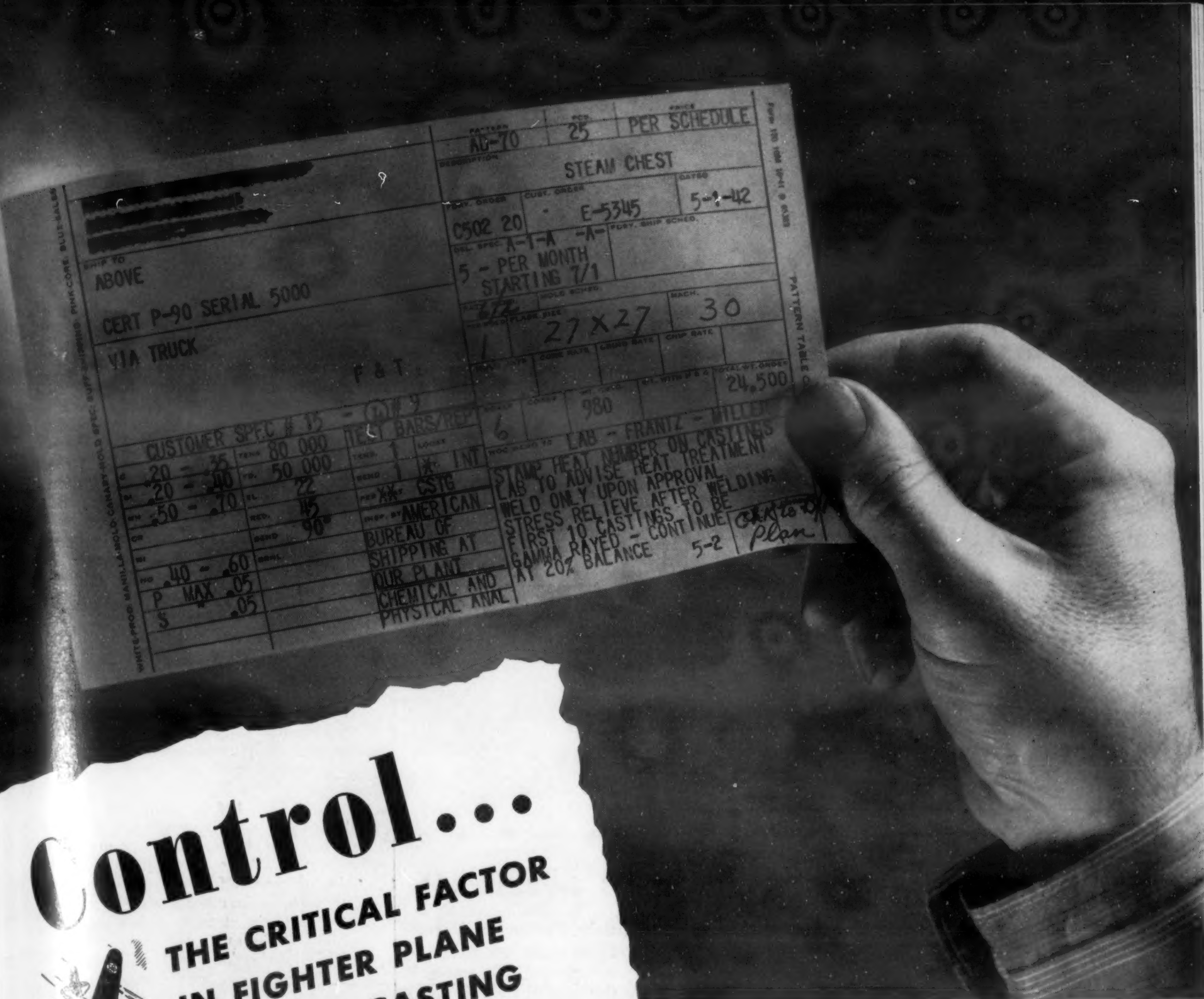
The American Coordinating Committee on Corrosion is contemplating revision of its confidential Directory of technologists actively engaged in studies on corrosion and its prevention. The Committee comprises delegates from the 17 major technical societies, together with representatives from the principal industrial research institutes and the National Bureau of Standards. Its Directory currently lists some 400 investigators in a diversity of corrosion-preventive fields, selected on the basis of questionnaires circulated to the membership of the Committee's member societies.

While it is felt that the Directory list is quite complete, there are undoubtedly some individuals who were not reached during the original circularization. Accordingly, the Committee now requests that all persons actively engaged in corrosion researches who have not been contacted by the Committee, write to the Secretary, Dr. G. H. Young, 4400 Fifth Ave., Pittsburgh, Pa. for further details and application forms for Directory listing.

New Source of Cleaning Machines

The organization of a Machine Division for the manufacture of mechanical metal washing machines, pickling machines, driers, ovens and burnishing equipment, is announced by the *Magnus Chemical Co., Inc.*, Garwood, N. J. The Company is well-known as a manufacturer of cleaning materials, industrial soaps, metallic soaps, sulphonated oils, emulsifying agents and metal-working lubricants.

A complete engineering service is offered, covering everything from the original problem through finished installation to practical operation. Considerable attention is being given to the development and manufacture of machines for use in connection with the dip and spray cleaning processes.



Control...

THE CRITICAL FACTOR IN FIGHTER PLANE OR STEEL CASTING

THOUSANDS of horsepower speed the fighter plane to combat . . . batteries of machine guns and cannon aim it for the kill . . . yet powerful motors and heavy armament cannot win a single "dog-fight" unless *control* instruments function perfectly.

This simple principle of control as the critical factor governs all operations at Lebanon—beginning with the writing of shop orders. These orders are not treated as routine detail. They are made into comprehensive "working plans" through which each department in the plant gains a thorough understanding of the customer's requirements.

Lebanon shop orders cover chemical and physical specifications . . . heat treatment . . . pattern equipment . . . delivery requirements . . . inspection—both by customer's representatives and by Gamma and X-Ray . . . sample castings for dimensional checking by customer or foundry . . . customer's requests for test blocks or coupons as well as all specific customer instructions . . . preference ratings . . . estimated or actual casting weights. These orders replace chance with *control.*

Control . . . and control again . . . control wherever possible . . . that is the premium Lebanon pays for the exceptional integrity, soundness and quality of Circle Ⓛ Castings . . . the castings which safeguard such reputations as those of Westinghouse and Jones & Lamson.

Lebanon metallurgists are studying future applications for alloy and carbon steel castings of controlled quality . . . and are ready to discuss significant developments with forward looking organizations.

LEBANON STEEL FOUNDRY · LEBANON, PENNA.

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *Stainless and Special Alloy* STEEL CASTINGS

CIRCLE L

AFA Convention and Foundry Show

(Continued from Page 808)

heat-treated to give a pearlitic malleable, side-by-side with a normal-analysis iron that develops a normal malleable structure—all in the usual malleableizing cycle. Alloys also retard graphitization so that spheroidization, with consequently increased ductility, can be carried out in the graphitizing temperature range.

The market for pearlitic malleable, competitive with normal malleable steel castings, forgings, stampings and even nonferrous metals is in the hands of the engineer, who still is insufficiently acquainted with its high physical properties.

Steel Castings

Some of the best papers at the convention were presented by steel casting men, and, so far as we were concerned, the very best discussions. For a while, too, it looked like Navy Week rather than Foundry Week, with engineers from the Norfolk Navy Yard and the Naval Research Laboratory good-naturedly instructing each other in the "right" way to make a mold.

Most intensively discussed was the use of "atmospheric pressure" in feeding steel castings. The practice was variously referred to as employing "blind risers," meeting a "late feed demand," setting up "favorable thermal gradients," utilizing "directional solidification" and even "cooperating with the inevitable."

It all started with the paper by H. F. Taylor and E. A. Rominski of the Naval Research Laboratory on "Atmospheric Pressure and the Steel Casting—A New Technique in Gating and Risering." Their work is an attempt to determine the practical value of the by-no-means-new "blind riser" —a riser that does not extend through the cope but is surrounded completely by sand —and to enunciate the principles governing the use of atmospheric pressure in feeding castings.

The paper borders on the classic and should be studied closely by all practical foundrymen eager to abandon the usual rule-of-thumb risering practices for something more rational. Not the least of the paper's features is the lucid explanation it provides of shrinkage, metal-feeding and mold-filling.

The basic principle whose applications are sedulously discussed in the paper is simply that liquid metal in a casting being fed is acted on by gravity forces and by atmospheric pressure—sometimes in the same direction, sometimes in opposition, with either predominant, depending on the location and height of the riser, the mass of metal, mold geometry, temperatures and thermal gradients, etc.

Full practical utilization of the effects of atmospheric pressure in blind risering is now possible through the use of a device patented by John Williams (U. S. Patent No. 2,205,327, 1940) comprising essentially a sand core inserted through the cope and into the top of the blind riser; this prevents the quick-forming shell of solidifying metal from sealing off the blind riser—or in other words, keeps the riser open to the atmosphere (via the permeability of the sand).

Blind risers making such utilization of atmospheric pressure effects have the following advantages: (1) hotter feed metal is attained because gating may be done through the riser; (2) bottom-gating is fully practical; (3) generally cleaner castings are achieved; (4) the blind riser can be placed in easier-to-remove locations, and obviates the heavy padding often necessary when open risers are used—thus lowering cleaning cost; (5) blind risers give increased yield through more economical feeding; and (6) they result in sounder castings.

Among the disadvantages cited were (1) the frequent necessity to use a larger flask; (2) the possibility of trapping dirt or dross; and (3) the existence of a patent on the sand-core device mentioned earlier.

Closely related to the "atmospheric pressure" paper was one by S. W. Brinson and J. A.. Duma of Norfolk Navy Yard on "Studies on Center Line Shrinkage in Steel Castings." Center line shrinkage is a defective condition of macroscopic shrinkage voids oriented in the direction of hottest metal and arranged in a characteristic pattern, and is most frequently observed in sand-molded basic steel castings solidified under inadequate temperature gradients.

The report shows how center-line shrinkage can be completely eliminated by suitable application of "padding" (a tapered disposition of metal on the walls of castings,

THE PROPERTIES OF LEAD

Chemical Corrosion Resistance

The high resistance of lead to the corrosive action of chemicals, particularly those commonly used—such as sulphuric acid—has led to its adoption as the standard material for equipment used in the manufacture, handling and transporting of chemicals. Generally, Chemical Lead is used, but if greater strength and rigidity are needed, antimonial lead may be employed. In some few cases, as in handling sodium chloride solution or hydrochloric acid, antimonial lead is more resistant to corrosion than soft lead.

RATE OF CORROSION

Chemical	Temp. °C	Loss in Weight in Grams /M²/100 Hours			
		Lead (Common)	Lead (99.99+%)	Common Lead (+.06 Copper)	Electro. Lead (+.10 Copper)
70% H_2SO_4	170°	7000	4600	1000	500
70% H_2SO_4	130°	1110	700	350	300
70% H_2SO_4	90°	38	19	11	9
70% H_2SO_4	20°	11	4	4	4
20% HCL	90°	230	100	300	310
20% HCL	20°	160	50	290	280
10% HCL	20°	28	16	55	45

In another series of tests in 10% sulphuric acid at 98° C for a period of 5 weeks, various elements were added to Chemical Lead (.06% Cu) to determine whether such additions improved the corrosion resistance.

	Loss in Grams Per 100 sq. cms.
Chemical Lead + .56 Sb, .27 Cd	1.25
Chemical Lead + .56 Sb	1.22
Chemical Lead + .10 Ca	.93
Chemical Lead + .026 Ca	.77
Chemical Lead + .02 Ni	.71
Chemical Lead — no addition	.66

A rise in temperature increases the rate of corrosion. In this test, lead containing .06 Cu was used.

Temperature °C	20°	60°	100°
	Loss in Grams Per 100 sq. Cms.		
35% H_2SO_4	.11	.22	.42
75% H_2SO_4	.12	.34	.60

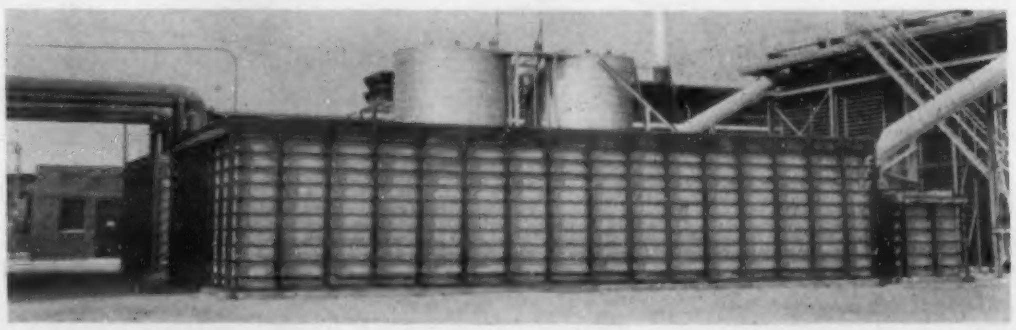
Among the metals commonly used in contact with salt water, only two, both of which are more costly, surpass lead in resistance to this type of corrosion. The following table shows the results of salt water corrosion on pure lead. In this case the samples were exposed to salt water solution of varying strength for a period of 200 days. The temperature of the solution was 8.5°C.

NaCl Concentration in per cent	0	.25	.50	.75	1	1.5	3	6
Loss in Weight in per cent	.0334	.2331	.2626	.4003	.6982	.567	.243	.127
Corrosion Factor	100	697	786	1198	2090	1696	726	364

It is of interest to note that the rate of corrosion increases up to 1% and thereafter decreases, a loss in weight of approximately .25% occurring at 2.7% which is the salt concentration of sea water.

The most outstanding use of lead because of its chemical corrosion resistance, is in the manufacture and handling of sulphuric acid.

•



All-lead chambers in Sulphuric Acid System, with lead piping leading in and out each end.

ST. JOSEPH LEAD COMPANY

250 PARK AVENUE • NEW YORK • ELdorado 5-3200

THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

the taper increasing toward the feed heads.) Padding induces progressive solidification, and its amount in any case depends on the height and thickness of the casting.

Although Brinson and Duma averred that only chilling and padding are able to produce the very high temperature gradients necessary for center line shrinkage elimination, Taylor claims that the application of the atmospheric-pressure principle through intelligent use of blind risers would also eliminate that defect in most of the castings made and studied by Brinson and Duma. If Taylor is right (and he says he has any number of test castings and radiographs to prove it), his practice would appear to be the more desirable, since it involves less "waste" metal and less machining in subsequent finishing.

On the other hand, it should be conceded that a tremendous educational job must be done on steel foundrymen before they will "get" the idea of atmospheric pressure. Not that it is especially complex nor that foundry engineers in the steel castings field are less intelligent or receptive than anyone else—it is just one of those things that requires a complete mental somersault before it is satisfactorily understood or used.

Welding of Castings

One of the features of foundry progress in recent years has been the fast growing use of "composite" structures made by welding castings to rolled plate or to other castings. This development, in conjunction with the sharply increased use of welding of castings for reclamation purposes, has made the subject of welding one of paramount interest to the foundryman.

A very practical investigation by S. E. Mueller, A. B. Smith and J. F. Oesterle on "Welding of Medium Carbon Steel Castings by the Metal Arc Process" gave much helpful information on the best practice for making sound, high-strength welds in steel castings.

Fusion welding has been employed for repairing minor defects in steel castings for many years. The metal arc process is most generally used today and little difficulty has been encountered in low carbon steels. High carbon steels and low alloy steels, however, that have air hardening characteristics, present problems to the foundryman. The following conclusions were drawn:

(1) The casting stresses and segregation have no detrimental effects on the weldability of plain carbon steels "as cast."

(2) No preheat is necessary for the satisfactory welding of plain carbon steel castings having a carbon content not exceeding 0.35% associated with 0.60% Mn. However, subsequent stress-relief or full anneal is desirable.

(3) Preheat is essential for the satisfactory welding of manganese-molybdenum steel castings having a carbon content of 0.35-0.40% associated with 1.25-1.50% Mn and 0.20% Mo. However, preheat alone is not sufficient to eliminate cracking in the structure adjacent to the weld but welding must be followed immediately by stress relieving to obviate such defects.

(4) In the welding of castings, owing to the high degree of restraint, shrinkage stresses are high and extraordinary precautions are necessary to avoid brittle martensitic structures (and consequential cracks) which cannot be removed by subsequent treatment.

(5) The effect of preheat on the maximum hardness in the heat-affected zone is far more effective for the lower temperatures than higher, and decreases with increased temperatures. Therefore, little is gained by 600° F. preheat over 300° F.

(6) The size or type of welding electrode has no effect on the maximum hardness created in the heat-affected zone due to welding.

(7) Increase in the size of electrode (rate of heat input) or preheat temperature results in a widening of the heat-affected zone.

A. T. Ruppe and A. J. Juroff of Bendix Aviation Corp., South Bend, presented a paper on "Salvage and Reclamation of Aluminum Alloy Castings by Welding."

It is possible to repair defects in No. 43 (5% S) aluminum alloy sand castings and to secure, in the welded region, physical properties equivalent to those of the parent metal. Castings of Alloys 355 (5% Si, 1 Cu) and 195 (4% Cu, 0.5 Si) also can be repaired by welding, but a slight loss in strength is to be expected, even if the castings are heat treated after the welding operation.

METALLURGICAL ENGINEERING shop notes

Prevention of Cracking in Welds

by A. K. Seeman
The Linde Air Products Co.

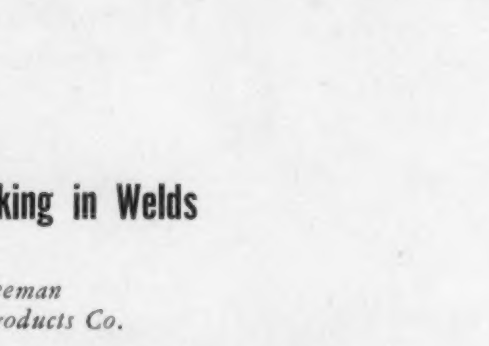
The considerable amount of contraction that occurs when weld metal freezes and cools is not generally appreciated. Disregarding the contraction of the molten metal in cooling to the point when solidification begins, the metal shrinks about 5 per cent in volume in merely changing to the solid state. An additional contraction of almost 1 per cent then occurs before the temperature has fallen to a yellow heat. Still another contraction of 1 per cent takes place when the metal cools from yellow heat to ordinary temperature. This sudden and considerable contraction must be controlled in welding to prevent cracking.

Often cracks are likely to appear in the base metal right at the edge of the weld, because, among other reasons, there the section is thinnest and its shape changes more or less abruptly at this point.

An obvious remedy for the edge-type of crack is to begin the weld at some point on the seam, and weld toward an outside edge rather than to start at an outside edge and weld inward along a seam. A slight compensating compression is thus brought to bear on the weld.

Conditions conducive to another type of cracking, can be overcome by a "double-welding" technique. This procedure is particularly useful in joining thick material to thin material, such as a forging to a tube. Welding with this technique is performed in two steps.

The first step (indicated "A" on the accompanying diagram) is to deposit weld metal on both materials, along the lines of the outer limits of the proposed weld. The weld metal should be fused with the base metal, but no attempt should be made to obtain deep penetration. The main weld (indicated "B" on the accompanying diagram) is then made between the two original weld deposits, and fused with them.



In this manner an abrupt change in section is avoided, cooling takes place less abruptly since the original weld deposits serve to preheat the base metal, and residual stresses in the base metal are removed prior to the main welding operation.

(For additional information on this subject, see the Shop Notes section of the Nov. 1941 issue of METALS AND ALLOYS. *The Editors.)*

Another interesting use for cellophane has been discovered recently. Sheets of the material are placed over sheet metal before forming the required part. Wrinkles, cracks and scratches in the drawn metal are prevented, and there is no tendency for the die to stick to the formed part. The tensile strength of cellophane is such that one sheet can be used several times. After rupture, the sheets can be used for smaller parts.

—*The Ohmite News*
Ohmite Manufacturing Co.

Sorting High- and Low-Carbon Steel Parts

by R. H. Grace

Two Shop Notes on the "how" of sorting mixed metal parts have appeared recently in this department. The first one published in our November 1941 issue, described a magnetic device for sorting small steel or iron parts that have different effects on a magnetic field. In our March issue, another method was presented for separating a mixture of high- and low-carbon steel parts by making use of the fact that high-carbon steel becomes harder and more brittle than low-carbon steel when quenched from certain temperatures. There is another method similar in some ways to the previous two, but offering a somewhat different procedure for a particular sorting problem.
—The Editors

At this time, when production is being pushed at top-speed, some steel mix-ups are bound to occur in metal-working shops. In such cases it is often advantageous, in order to save time and material, to have a nondestructive method of sorting the mixture. The following is a description of a nondestructive method for sorting high- and low-carbon steel parts, which has proved successful in practice.

(Continued on page 834)

Approximately 20,000 stampings had been made and sent to the heat treating department before it was discovered that SAE 1010 had been mixed with SAE 1095. On this particular part it appeared feasible to use either steel, provided one could be separated from the other and the proper heat treatment applied.

To separate the mixture, use was made of the fact that hardened steel retains magnetism to a greater degree than does soft steel. All of the parts were heated in a controlled atmosphere furnace to 1425 deg. F. and quenched in oil. After the heat treatment they were placed across the poles of a U-shaped magnet for approximately 10 sec. If no suitable permanent magnet is available, a magnetic chunk can be used.

The magnetized parts were then spread out on a wooden table for sorting. A bar of soft iron, in this case the "keeper" of the magnet, was brought into contact with each piece. Parts of SAE 1095 retained sufficient magnetism to be appreciably attracted to the bar, whereas parts of SAE 1010 were unaffected.

The hardened SAE 1095 parts were then tempered at 800 deg. F.; the soft SAE 1010 parts were retreated in cyanide at 1600 deg. F. and oil quenched. Toughness and wear resistance tests showed the finished products to be acceptable.

Avoiding Cracked Castings

One reason why cracked castings are a headache, aside from the cost angle, is that there are so many possible causes of the trouble. When cracks occur before heat treatment, for instance, the cause may be improper casting design, insufficiently baked cores, poor rigging practice, failure to relieve strains by freeing sand, changes in analysis, or one or two other possibilities.

The Metallurgical Dept. knew it had a task on its hands when an abnormal percentage of manganese steel castings at the Amsco Foundry in Denver had to be scrapped because of hot cracks. They went through the list, but found no appreciable variation from practices that had proved satisfactory in the past. Finally, they discovered that the residual phosphorus in the steel had increased slightly, and this small clue was immediately investigated.

The foundry uses arc melting (to conserve manganese), so it was evident that the excess phosphorus was somehow put into the charge. Inferior scrap was the most likely source, and as a test a number of frogs were poured from carefully selected scrap and were compared to frogs poured with unselected scrap. The result was startling—14 out of 20 frogs from the inferior scrap had to be discarded, while only 1 frog out of 14 from selected scrap was cracked.

This established the cause of the hot cracks, and it remained only to figure out the exact effect of phosphorus on the strength and ductility of the final castings so that a maximum phosphorus allowance could be set. Tests were run at a constant temperature (2100 deg. F.) with the following results:

Phosphorus %	Strength /in.²	Ductility % E-2 in.
.043	3550	29.0
.106	2900	6.0
.210	1350	2.5
.280	1000	2.5

(These figures of strength and ductility relate to non-heat-treated castings.)

The drop in tensile strength, and particularly in ductility as the amount of phosphorus is increased, is striking. As a result of further calculations, a maximum amount of this element was established, with losses for hot cracks reduced to a practical minimum.

—*The Amsco Bulletin*

Alloy-Addition Weight Table

The following is a handy table for foundry engineers and others who want to find out quickly how much alloying agent, by weight, is required per 100 lbs. of metal to obtain certain alloy percentages in the casting.

In using the table, it must be remembered that the amounts given represent the "ideal" or 100 per cent recovery, and take no account of alloy losses in melting.

Alloy Percent Desired in Casting	Ferro-Chromium 70%	Copper 99%	Ferro-Molybdenum 65%	Ferro-Manganese 80%	Ferro-Silicon 50%	Ferro-Silicon 90%	Nickel "F" 92%
	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.
0.20	0 - 5	0 - 3	0 - 5	0 - 6	0 - 8	0 - 4	0 - 3
0.30	0 - 7	0 - 5	0 - 8	0 - 7	0 - 10	0 - 6	0 - 5
0.40	0 - 9	0 - 6½	0 - 11	0 - 9	0 - 13	0 - 8	0 - 7
0.50	0 - 11	0 - 8	0 - 14	0 - 12	1 - 0	0 - 10	0 - 9
0.60	0 - 14	0 - 10	1 - 0	0 - 15	1 - 3	0 - 12	0 - 11
0.70	1 - 1	0 - 12	1 - 3	1 - 1	1 - 7	- - -	0 - 13
0.80	1 - 3	0 - 14	1 - 6	1 - 2	1 - 11	- - -	0 - 15
1.00	1 - 8	1 - 0	1 - 10	1 - 3	2 - 0	- - -	1 - 1
1.25	1 - 13	1 - 4	2 - 0	1 - 5	2 - 8	- - -	1 - 5
1.50	2 - 2	1 - 8	- - -	1 - 14	3 - 0	- - -	1 - 10
1.75	2 - 8	1 - 12	- - -	2 - 6	3 - 8	- - -	1 - 15
2.00	2 - 14	2 - 0	- - -	2 - 12	4 - 0	- - -	2 - 3
2.25	3 - 4	2 - 4	- - -	3 - 2	4 - 8	- - -	2 - 7
2.50	3 - 9	- - -	- - -	3 - 8	5 - 0	- - -	2 - 11
2.75	3 - 14	- - -	- - -	4 - 0	5 - 8	- - -	3 - 0

—*Pig Iron Rough Notes*
Sloss-Sheffield Steel & Iron Co.

Old telephone books can be of considerable use in the foundry. By placing pages from the books over openings in the molds, dirt can be kept out. When the molten metal is poured into the mold, the intense heat burns the thin paper away instantly and without residue—leaving the casting free from foreign matter.

—*Trade Winds*
Wright Aeronautical Corp.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

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1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining • Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment • Melting and Manufacture of Non-Ferrous Metals and Alloys • Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces • Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice • Foundry Practice, Furnaces, Equipment and Materials • Manufacture of Die Castings

CONTENTS

Porosity in Aluminum Castings

Condensed from *The Foundry*

The causes and elimination of porosity are not understood clearly. Porosity may be traced to the following: (1) metal, (2) gating, (3) trapped air and gas, and (4) shrinkage. By classifying the various types of porosity, it is easier to recognize them.

The first type of porosity, caused by the metal itself, is easily identified because the casting is porous throughout. Sections show many "salt and pepper" spots over the entire surface.

Gas may be absorbed during melting, with the help sometimes of such incorrect melting processes as too quick heating; disturbance due to dropping cold metal into liquid metal; metal surface exposed before pouring; improper stirring, fluxing and skimming.

Porosity will vary with the chemical composition. An alloy having 5% Si, 1 Cu, 0.5 Mg and the rest aluminum, will pick up porosity more readily than one of 95% Al and 5 Si.

To eliminate porosity use a clean pot, coat with a film of lime-wash and dry. Charge the furnace with small pieces of gates and risers and load the remainder of metal so that the metal does not bridge. Heat the pot to a cherry red. When the metal becomes liquid form a cover on the surface with flux.

Heat the metal to 1250° F., or if titanium is used to 1350° F. Flux the metal by adding some flux and skim with an iron rod coated with lime-wash. Skim off the oxide and impurities and cover with the flux. Allow to freeze to about 11[illegible]0° F., then reheat to the desired temperature and skim off the flux. Pour the metal as soon as possible. If there is porosity in the metal, small bubbles or pin holes will appear.

Porosity from improper gating appears as large and small holes. Proper gating is based on the size of sprue gates, proper placement of choke in the sprue gate or runner, and the number, location and size of gates.

The cross section area of sprue should be smaller than of gates and that of gates smaller than the cross section area of runner. If only one runner and gate is needed, the choke should be placed in the runner. If a number of gates are used, the choke should be in the gate.

As to the number of gates to use, the size and shape of casting, characteristics of the metal and pouring temperature are to be considered. When possible, the gates should enter at the bottom of the casting to allow the metal to flow upward.

Porosity caused by trapped air and gas appears as small holes on the cope side of the casting. Gas is formed when the metal fills the mold. This gas can escape only through the sand and, therefore, the sand should be permeable. Proper vents are essential. Cores forming the cope side should not have skin hardness or pin holes will appear.

Porosity due to shrinkage is more or less a surface condition, but it can go very deep without a shrink occurring. It appears when there is a variation in wall

thickness, insufficient feed to heavy sections, or lack of pressure. These may be taken care of by a fillet or proper chill. Insufficient feeding is due to risers being too small. (William Wilson, Jr. of Bendix Aviation Corp. in *Foundry,* Vol. 70, Feb. 1942, pp. 64-65, 151-152.)

Inside the Blast Furnace

Condensed from *Foundry Trade Journal*

Description and analysis of experimental work from the view point of physical changes which the various components of the charge undergo on their passage from the charging platform to their removal from the furnace at the tap hole show some interesting results. No measurements were made of diffusion conditions in the solid phase; although phenomena of this type may take place in the blast furnace, the time they occupy during the descent of the burden would appear to be too short for them to have any far-reaching practical effect.

Swedish ore remained loose in both atmospheres at 1800° F. and sintered at 2000° F. This ore showed slight expansion between 1475° and 1800° F.; contraction became more pronounced at 2200° F. The expansion and contraction appear to be independent of the external pressure applied to the ore.

The Swedish ore commenced to soften under the lower pressure at 2230° F. and fused completely at 2320° F. Increasing the load to 27 lbs./in.^{2} lowered both softening values by about 180° F. The melting points measured represent incipient fusion, for as the temperature is further raised the ore lumps pass through various stages of fluidity.

Incipient deformation of the ore lumps, *i.e.* the rounding of the edges and corners, does not affect the smelting process, although subsequent stages of deformation have varying effects. Fritting, the temperature of which has been measured for various ores, causes a slight agglomeration of the particles, especially of those of dust fineness. Sintering proper has a more marked effect than this, the ore particles and the dust then becoming firmly cemented together.

While up to this point the ore lumps and particles can easily slide over each other, their motion through this temperature zone becomes sluggish, the coke, coke dust and lime alone preventing the charge from caking into a compact mass. As the temperature rises further, the first signs of fusion are noticed. Viscous melting clogs the charge and retards its descent. On a further temperature rise, zones of fusion are formed and the lumps begin to run.

The primary basis for the economic evaluation of iron ores is naturally their iron content, although they can also be evaluated on the basis of their physical behavior. (*Foundry Trade J.*, Vol. 66, Feb. 12, 1942, pp. 101-104; translation of an article by F. Hartmann, originally published in *Stahl u. Eisen.*)

Tearing of Steel Castings

Condensed from *Foundry Trade Journal*

The disastrous effect of the hot tearing of steel castings of complicated design is well known, and is often attributed to the resistance offered by the sand to the contraction of the casting. The experiments described were made to uphold or disprove this contention.

To eliminate such factors as non-uniformity in the direction of contraction, the pattern selected for these experiments was a simple bar 4 ft. long, 1½ in. wide and ⅜ in. thick. From the large number of tests carried out it would appear that hot tearing is due rather to the resistance offered to contraction by the bulk of sand than to the nature of the sand itself.

When steel castings are stripped from the flask, it is observed that there is a thin layer of burnt sand between the face of the casting and the main body of the sand. This layer is very friable and, provided the refractoriness was originally sufficient, it is easily removable from the casting. However, after being submitted to a temperature as high as that of molten steel, there is no strength in this sand.

It is not likely, therefore, that there is any resistance offered to the contractional

movement of the casting. It is possible, on the other hand, that the friction between molten metal and the sand increases with increase in coarseness of the sand. This was observed when casting at the same temperature in different sands. In the case of a coarse sand, metal cast at the same temperature appeared to take longer to fill the riser than when cast in a finer sand. The head of metal in each case was the same, but the rate of pouring was not controlled which might account for it.

No attempt is made to explain sulphur segregation near the runner and riser, but it is felt that the temperature at the crucial moment during contraction will decide where the casting tears. In every test carried out this was near the runner—that is, in the hottest region.

Given uniformity of temperature, the bar is quite as likely to crack near the riser as near the runner. The degree of purity might possibly influence the location of the tear in this case.

With regard to casting temperature, the only deduction possible from the varied number of casting temperatures employed is that tearing occurs some time after solidification, probably very soon afterwards. It is known that at such temperatures steel is very weak, and it is also known that metals contract at a quicker rate at elevated temperatures than at lower temperatures. These facts when taken together indicate that tearing occurs somewhere in the neighborhood of the solidification temperature.

It has been shown that, provided one runner is set at a sloping angle, hot tearing will not occur. The casting temperature was obtained by means of a tungsten-molybdenum immersion couple. (J. H. Andrew & H. T. Protheroe in *Foundry Trade J.*, Vol. 66, Feb. 5, 1942, pp. 83-86.)

Dolomite Bricks in Steel Furnaces

Condensed from *Iron & Steel*

The further replacement of magnesite and chrome-magnesite bricks in open hearth and reheating furnaces by dolomite bricks would reduce the strain on shipping and leave home-produced (*i.e.* British-produced) magnesite available for essential requirements.

Dolomite, even after high-temperature calcination or electrical fusion, perishes fairly rapidly, owing to hydration of the free lime. It can be rendered stable by firing it in a rotary kiln with a suitable admixture of serpentine and dicalcium-silicate stabilizers. Bricks made from such clinker consist essentially of magnesia and tricalcium silicate ($3\ CaO\ .\ SiO_2$). They should not contain free lime, but may contain some stabilized beta dicalcium silicate.

Given adequate control of the clinker and brick production, such dolomite bricks compare favorably with magnesite bricks, although they have a somewhat lower resistance to spalling and to slags high in iron oxide. These bricks have been used with complete success in the tapholes, hearths and banks of fixed open hearth furnaces, in the banks and sub-hearth of tilting furnaces, and in reheating furnaces operating at temperatures at which scale formation is considerable.

Semi-stable dolomite bricks, *i.e.* dolomite bricks in which the lime is protected from hydration by a coating of flux, have a higher thermal-shock and slag resistance, and have given a life equal to that obtained with chrome-magnesite bricks in fixed-furnace back walls. Magnesite-stabilized dolomite bricks have given encouraging results in preliminary trials in tilting-furnace back walls. (T. Swinden & J. H. Chesters in *Iron & Steel*, Vol. 15, Nov. 10, 1941, pp. 81-86.)

Light-Weight Ingot-Mold Stool

Condensed from *Steel*

In 1935, the life of small solid stools used by the author's firm averaged 92 heats. At that time a light stool for 19-in. x 42-in. ingots was developed by making it heavier at the center and lighter at the ends. This stool weighed 3200 lbs., compared with 4700 lbs. for a solid stool for the same size ingot.

The new stool was cored out at each

end and its thickness at the center increased 1 in., making it heavier and stronger where the stream of molten steel hits during pouring. Increased life of stool and decreased number of stickers resulted. The life of the first 15 experimental stools averaged 279 heats, ranging from 105 to 460 heats per stool.

Following this test, all stools for the open-hearth shop were made of this light-weight design. During 1937 the average life was 152 heats per stool. The largest number of heats obtained from the light-weight units was 518. The centers of this stool and of one with a life of 501 heats were cut out about 5 in. when they were taken out of service.

During the last 2 yrs. light-weight stools designed for 20-in. x 57-in. heats have averaged 104 heats. The weight of this stool is 5656 lbs., compared with 8300 lbs. for a solid stool for the same size ingot.

Occasionally the life of a light-weight stool reaches 250 heats. The stool for the 20-in. x 57-in. ingot is 44 in. wide, 77½ in. long and 10 in. thick at the center. The end section is 4½ in. thick and the 3 ribs beneath the end section are 4½ in. thick. Four different-size ingots are poured on this stool, which decreases the life considerably.

An all-welded ingot buggy is used for carrying the molds and stools. The life of stools on this buggy is at least 15% better than that obtained from the cast buggies, as the full length of the stool is supported by the welded buggy.

Stool life is shortened when a long stool is used on an old-style cast narrow buggy, which does not support the outside ends of the stool. (W. W. Bergmann of American Rolling Mill Co. in *Steel,* Vol. 110, Mar. 9, 1942, p. 86.)

Steel from Cupola-plus-Converter

Condensed from *The Foundry*

Factors responsible for the converter's comeback are: The development of practical means of reducing sulphur content in cupola metal, and the development of the electric eye to aid the converter operator.

Owing to the availability of means for sulphur control, a much wider range of raw materials can be used. The proportion of scrap can be varied greatly. The charge may consist of nearly all steel scrap plus silicon-bearing alloy in the amount necessary to supply the required silicon.

Like other steel-making processes, the converter depends upon oxidation for the refining operations. The steps are: (1) Melting cycle; (2) superheating; (3) oxidation of metalloids to low percentage; (4) removal of excess oxides; and (5) adjustment with recarburizers to required composition. This cycle is accomplished in 15-17 min.

The cupola melting rate should equal or slightly exceed the amount of metal desired for the converter charge. The desulphurizer —Purite or other alkali—should be put in the ladle before tapping. The slag is skimmed off, and the hot metal is transferred to the converter and poured into its nose.

The converter is preheated for the first heat by oil or gas so the lining is at about 2400° F. The converter is tilted back so the metal is at the lower level of the tuyeres. The blowing angle should be between 6° and 10°.

The elimination of metalloids takes place as follows: (1) The silicon period lasting about 5 min.; (2) the boil, a period of violent reaction in which carbon and most of the manganese is removed; and (3) the carbon period in which the carbon is burned out. An electric eye automatically registers the intensity of the flame and also the end point of the operation. The end of the blow is marked by a dropping of the white flame and a trace of brown smoke at which point the vessel is turned down and the air turned off.

At this time, the carbon is about 0.05% and the manganese and silicon 0.10%. In recarburization, ferromanganese and hot cupola metal are added in quantities to bring the carbon and manganese to the desired percentage. About 1% Al is desirable. Carbon may vary from 0.25 to

3.50%, silicon from 1.75 to 2.25% and manganese from 0.60 to 0.70%. By controlling the silicon of cupola metal, temperature of steel can be regulated between 2900° and 3200° F.

Sulphur is picked up in the cupola from the coke, and is, therefore, higher in the molted iron coming from the cupola spout than in the charged metal. It can be controlled by treating with alkalies in the ladle. No practical method of phosphorus removal is available; therefore the original charge must not be over 0.04% P. (A. W. Gregg of Whiting Corp. in *The Foundry*, Vol. 70, Mar. 1942, pp. 66-67, 159-160.)

Basic Open-Hearth Refractory Practice

Condensed from *Blast Furnace & Steel Plant*

Algoma was a pioneer in the use of insulation and developed its own silica brick plant. Hearths are maintained with a variety of domestic grain magnesite, called "Magnifrit" ("Basifrit" in the U. S.) used together with raw dolomite. The mineralogical composition of Magnifrit is 65-67.4% periclase, 18.9-20.2% dicalcium silicate, 4.7-4.8% calcium ferrite, and 13.7-14.7% tetra calcium aluminum ferrite. The periclase and dicalcium silicate are very refractory and the iron-alumina fluxes shrink the clinker during manufacture and permit rapid setting in the open-hearth furnace.

Until recently Magnifrit was used for burned-in magnesite bottoms. "Ramix" is now being used for installing hearths. This has resulted in much higher yield of steel over burned-in hearths and a large reduction in the amount of grain magnesite used for fettling in the first 2 campaigns. Of the various advantages over burned-in magnesite, the principal one is the time saved in getting the furnace into production.

Tap-holes are constructed of "Plastic 695"—primarily a specially graded, chemically bonded plastic of non-slaking magnesite and chrome ore. Excellent tap-hole life is secured on regular operations but will be much higher on rebuilds. This plastic is also used for various quick patches.

In order to use chrome-free materials wherever possible, quick patching of the hearth proper and at slag line is now done largely with "Ramix" of wetter-than-ramming consistency. Subhearth design of rebuilt furnaces conforms to that of new open-hearth furnaces. First is 2½-3 in. of insulating concrete. This is followed by 7½-9 in. of fire-clay brick, 13½ in. of "Magnecon" brick, and the working hearth. The Magnecon brick are placed as an inverted arch with chrome cement joints, or as the conventional flat construction.

"Magnecon" is a magnesite-chrome brick, said to have a higher spalling resistance than other basic bricks. It consists essentially of periclase, stabilized dicalcium silicate, and inert spinel. It is more resistant to hydration than magnesite of higher purity and resists basic open-hearth slags and dusts as well as fused-in hearths.

The backwall is essentially magnesite brick with an inner facing of large lumps of hard Transvaal chrome ore set up in a special chrome-patching cement. At present, American Olivine is being tried, because of the unavailability of chrome ore.

The roof is constructed of 18 and 22½ in. silica brick. Roof life has been extended to 350 heats by adoption of temperature control and the use of a special silica cement for full joints to reduce spalling and lengthen the life of individual bricks. Severe cutting over the tap-hole governed the amount of roof replacement.

To get a better balance of life of the whole roof, the most vulnerable part was replaced with a partial ribbon of basic brick. The standard practice now is use of the skew and several courses of imported basic brick of special composition.

Tests have been made on 60-ton ladles with different types of magnesite linings. In each case the lining failed prematurely from chilling and skulling. Basic linings are successful in small ladles up to 4 tons for manganese and special alloy steels. (J. W. Craig of Canadian Refractories, Ltd. in *Blast Furnace & Steel Plant*, Vol. 30, Feb. 1942, pp. 241-245.)


ATTACK!

The Secondary Copper Situation

Condensed from a report of the Advisory Committee on Metals and Minerals, National Research Council, National Academy of Sciences

This unusually comprehensive report was prepared early this year by E. E. Thum, editor of "Metal Progress," on behalf of the Advisory Committee on Metals and Minerals, at the request of the (then) OPM. The report, released by the WPB at this time, has been generally praised for its analytical clarity. This digest can do no more than review the features of major utility to our readers, and for the wealth of additional data the original, complete version, obtainable from the office of E. J. Hergenroether of the WPB, should be consulted.—The Editors.

About one quarter of our secondary copper has normally been put back into circulation by the country's 8 electrolytic and 2 furnace refineries; this was the cream of the scrap collections, both of new plant scrap and old discarded scrap copper (so-called "demolition metal"). About 50,000 tons a year was new scrap from the industry that fabricates unalloyed copper; it represents a fairly constant load of "material in process." Much of this high-grade metal absorbed by the refineries can better be used, without refining, in the manufacture of "composition ingot."

Where It Originates

Statistics for the total amount of secondary copper include sales of new plant scrap as well as demolition scrap (junk). Obviously the first category is a circulating load of metal in process; only the reclaimed junk represents a new supply of copper. It is, roughly, two thirds of the "total 2,857,100 tons secondary copper" reported in the statistics for the period 1935 to 1940 inclusive.

Owing to the fact that a large proportion of this 2,000,000 tons of old scrap of clean, choice grades is absorbed directly by refineries, brass mills and non-ferrous foundries, the residue is increasingly hard to reclaim into usable composition ingot. It is believed that present official regulations tend to concentrate impure metal in plants which cannot use it promptly and effectively. Likewise, the amount of junk will decrease unless special efforts are made to encourage its collection.

Two problems, therefore, seem to be in need of some detailed study: First, whether the refineries, both furnace refineries and electrolytic refineries, will have sufficient capacity to produce pure copper from expanding mine production and yet absorb more secondary metal which may be expected to appear, and second, the problem of "conversion contracts"—namely, how to restart an increasing flow of impure metal back to the smelters for separation into its components and their conversion into useful form.

The Position of the Ingot Remelters

Manufacture of composition ingot by remelters is doubling in volume, and is now on the order of 300,000 tons ingot annually; the demand is primarily for analyses with low impurity limits (Army and Navy specifications) at the very time when there is no outlet for low-grade ingot into normal civilian channels, when the sources of clean, old scrap are drying up, and when good plant scrap must—by OPM order—be returned to the originator of the raw material.

Mills and foundries, particularly the latter, have entered the old scrap market and absorbed unusual tonnages of metal of desirable composition, thus degrading the average quality of the remainder available to the remelter of alloy ingots.

To meet the immediate demands, enough unalloyed copper plant scrap and No. 1 demolition copper must be made available to ingot remelters to enable them to meet the demands of high priority castings to be made in the non-ferrous foundries.

This aforementioned 300,000 tons of alloy ingot, containing approximately 200,000 tons of copper, is now being used almost exclusively for priority materials. A recent study indicates its ultimate destination. Important fractions are contained in yellow brass ingots, in bearings and bushings, and in bronzes with low impurities.

"Remelters" comprise numerous firms, a dozen or more of importance as well as 3 or 4 dozen small concerns, which are prepared to accept some 30-odd classifications of copper, brass and bronze scrap (either as manufacturers' new plant scrap, or old

scrap demolition metal from wholesale junk dealers) and remelt it into ingot of known composition. Their product is the principal source of ingot metal of the non-ferrous foundries; only one of the principal remelters normally produces rolling mill billets of unalloyed metal (wire bars) or composition (free-cutting rod analyses).

Use in Brass

An accumulation of at least 100,000 tons a year of "orphan" high zinc brass is to be expected, denied to civilian consumption and unwanted by the war industries. To this must be added a sizable amount of even more impure metal which has been sent to smelters under the terms of "conversion contracts," now prohibited. Reclamation of high zinc brass into alloy bronze ingot of analyses desired by the armed forces involves dilution with 3 times its weight of low zinc alloy.

Another outlet is smelting and separation into its components; it is recommended that the smelting processes and available capacity be appraised, with the view of reclaiming the copper, zinc, tin and lead in this surplus brass as separate metals of commercial purity.

Bearings and bushings are now bought by the armed services in large quantity with lead limits so low that 2.5-4 lbs. of virgin copper, tin and zinc must be melted for every pound shipped as bearings. Ample experience in peacetime industrial machinery proves that such low lead limits are quite unnecessary and a competent A.S.T.M. committee proposes to modify them so that secondary metal can be utilized.

Bronzes

Railroad rolling stock uses journal bearings made of a 25-lb. arch casting of lead bronze, lined with 3/16 in. of babbitt. Successful and long experience with ball and roller bearings in engines and passenger cars suggests that these be so applied, up to the production capacity of the present mechanical bearing industry. All remaining bronze railroad bearings should be made exclusively of secondary metal.

Since experience in the automotive industry amply proves that steel-backed bearings lined with thin layers of antifriction metal are superior bearings, a committee of appropriate experts should vigorously press a program looking toward such a substitution in the railroad industry, which when successful, would avoid the annual consumption of about 25,000 tons of alloy ingot, and make available for reclamation a large part of the "sink" of 250,000 tons of copper, tin and lead.

Many thousands of tons of bronze castings for the Navy, Army and aircraft now require such low impurities (especially lead) that much virgin metal must be used in their compounding. It is recommended that civilian engineers and service officers intensify their work in making an immediate and joint study of existing drawings and specifications, and limit the use of low-impurity alloy strictly to those portions of present assemblies that undoubtedly require them.

Copper Irons and Steels

At least 20,000 tons of copper will be used annually in the iron and steel industry. Most of this copper has not yet appeared in the statistics. This metal is permanently lost to non-ferrous uses.

Much of the low "copper bearing" irons and steels can be made without copper additions by selecting steel scrap and pig iron high in copper. To secure a suitable supply of such iron, it may be necessary to reopen some of the old mines in the Cornwall, Pa. region, which produced pig iron containing up to 1% Cu. The copper alloy steels should utilize these sources plus copper shot made from demolition copper too high in iron for non-ferrous foundry use.

If the emergency demands it, copper may be used to substitute for some of the scarcer alloying elements in steel and cast iron. The fact must be faced squarely that the importation of chromium and manganese ores has been substantially reduced.

It may be that one of the best war uses for copper will be its generous use in the production of alloy steels and cast irons. Its use for this purpose will naturally be determined as a compromise, taking into consideration the various "must uses" for copper, and its availability as compared with that of other alloying elements for steel or cast iron. (E. E. Thum in a National Academy of Sciences Report to the WPB, Jan. 6, 1942, 19 mimeographed pp.)

Foundrymen have reduced core-baking time and increased core-oven output as much as 50% with Truline Binder.

And that is only one of the benefits of Truline Binder in steel, grey iron, malleable, and non-ferrous foundries. Others are:

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Truline Binder permits the use of as much as 75% black sand in many cores now using new sand and slower-baking binders.

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CONTENTS

Flame-Hardening Practice

Condensed from *American Machinist*

The depth and contour of the hardened tooth area are still controversial subjects, but in general are a function of the diametrical pitch. A decrease in speed of flame hardening greatly increases the depth of hardness. Preheating, if necessary, usually increases the depth of hardness but decreases the degree.

Flame hardening adjustment must be carefully made so that the tooth is uniformly hardened on both sides. Gear teeth of 10 D.P. and smaller may be hardened by spinning the gear and dropping it into a quenching bath. Progressive hardening works well with gears from $4\frac{1}{2}$ to 9 D.P. (tip, torch, and quench travel on a radiagraph). For gears 5 D.P. and larger, the progressive method is used with heating and quenching tips mounted on a gear hardening yoke.

Bevel, spiral bevel, zerol bevel and hypoid gears are best hardened on a flame hardening machine with automatic indexing mechanism and variable rate of tip travel. Teeth of racks may be hardened with the same procedure and apparatus as employed on spur gears.

If flame-hardened gears are correctly aligned (with uniform depth of hardening on sides of teeth), the gear will have nearly twice the wearing load-carrying capacity of an unhardened gear. Since the core is not affected by the flame hardening, it can be heat-treated to the required properties before the tooth is hardened. The flame hardening is usually carried out after finish machining as the flame hardening does not affect the accuracy of the gear.

Flame hardening sprocket teeth is comparable to the hardening of gear teeth described above. Fine screw threads of water quenching steels may be flame-hardened by the progressive spinning method, with a separate water quench trailing the flames. Larger screw threads require spiral progressive procedure with flames directed at thread root.

In the case of large Brown and Sharpe or Acme screw threads or small worm threads, flames are directed at both sides of the thread with flame centers impinging slightly below the thread pitch line. On large worm threads, gear hardening tips are used that heat and quench both faces of threads simultaneously. Sheaves are best hardened with contour-integral heating and quenching tips, which provide uniform heating and quenching over the required area.

Small internal hemispheres are best flame hardened by the spinning method although larger diameters may require the progressive method. External hemispheres are hardened by a curved combination flame and quench tip or by several small tips.

Sometimes, as in the case of thin sections, distortion can be minimized by applying the flame to each side rather than to the edge which is to be hardened. In other applications, distortion is avoided by flame hardening unconnected paths rather than the entire surface, or by immersing most of the object in a circulating water

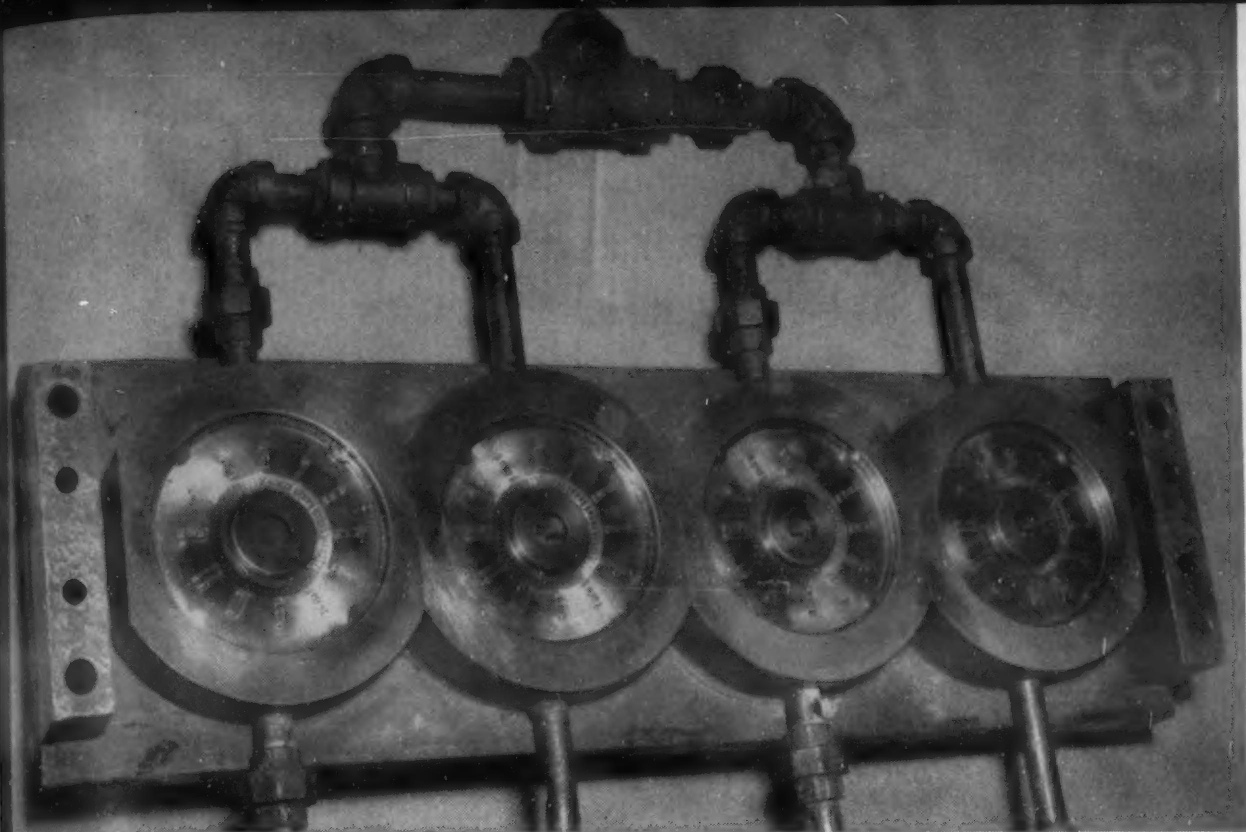

Fig. 1. Dies from which American Insulator Corp. has molded plastic faces for clocks. These tools were Vapocarb-Hump hardened and Homo Tempered.

Fig. 2. Heat-treater at Homo Tempering Furnace, where forced-convection air tempers gently, accurately and quickly.

HOW AMERICAN INSULATOR CORP. "VAPOCARBS" ITS MOLDING DIES

Plastic-molding dies which have absolutely flawless surfaces are, of course, nothing new to the American Insulator Corp., of New Freedom, Pa. The production of such dies, however, took a sharp turn upward when the Company started, a few years ago, to heat-treat them by the Vapocarb-Hump hardening and Homo tempering methods.

For, the ultimate perfection of the dies had been produced by "polishing" to remove the pits created by heat-treatment. But, Vapocarb-Hump hardening, plus Homo tempering, produce no such pits. Dies remain perfectly smooth, and hours or days of polishing are saved, at a time when every hour counts.

Vapocarb-Hump and Homo Methods are easy to use. The cycles are as follows:

"Perfect-Surface" Hardening Routine

The hob for a die is absolutely bare when put into the Vapocarb-Hump Furnace (Fig. 3) for hardening.

As it heats, its temperature is recorded on the Hump Method controller's chart, (at right in Fig. 3). On the same chart, the difference between hob temperature and temperature of furnace is also recorded. These two temperatures help the heat-treater to set the controller for the correct *rate* of heating. Rate which is correct will help, later on, to prevent unexpected warp, when the tool is hardened by quenching.

At about 1200 F, the heat-treater starts Vapocarb gas into the hardening furnace. This gas forces all air out, blanketing the tool and assuring that it will leave the furnace with its engraved lines as smooth and sharp as when it entered.

Quench by the Hump

When the hob reaches its critical, a "Hump" appears on the record curve. This Hump helps the heat-treater to check his judgment of the quench point; and, since proper quench point helps make the tool strong enough and hard enough for its severe service, the Hump helps secure maximum life.

No Guesses About Tempering

After quenching, the hob is checked for hardness, and tempered to "draw the tool back" to its final hardness. Here the Homo Method (Fig. 2) heats it gently but quickly, to the exact desired point, and holds it for any desired time.

When it leaves the Homo Furnace, the hob is completely heat-treated.

Carburizing of Hobbed Dies

The dies punched with the hob (for example, the clock-faces shown above) are carburized in the Vapocarb-Hump Furnace which hardened the hob, and are tempered in the Homo Furnace. Thus one pair of furnaces does the whole heating job, on any tool steel from punch alloys to hobbing iron.

Further details of Vapocarb-Hump hardening and Homo Tempering Methods are in Catalogs T-621 and T-625, which will be sent on request.

Fig. 3. Vapocarb-Hump Hardening and Homo Tempering equipments in American Insulator's heat-treat. Controllers in background; operator is at Vapocarb-Hump Furnace. Note convenient placing of all units.

NEW HEATING PRINCIPLE BLASTS TRADITION!

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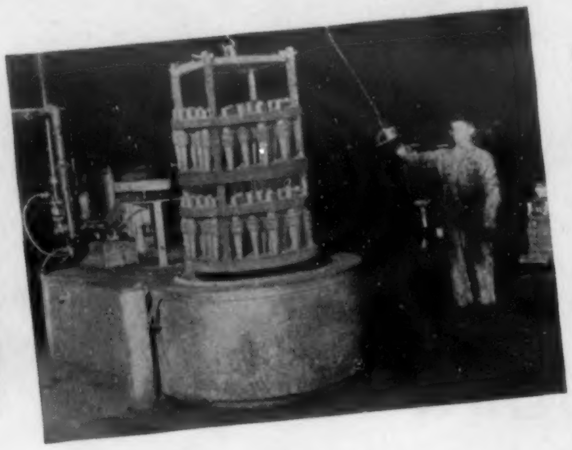
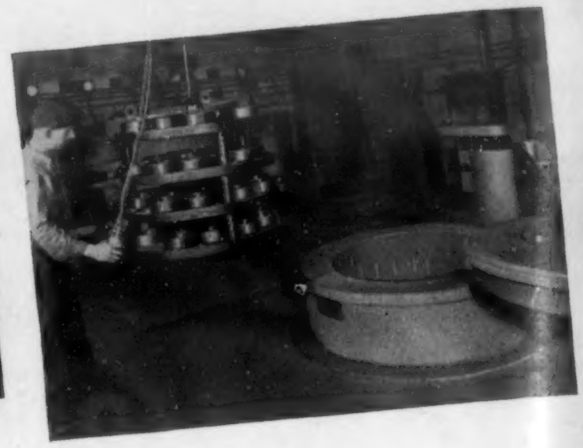




ALL THE ADVANTAGES

of 100% forced convection heating

are now available in the annealing, normalizing, and hardening ranges. For years, textbook theories and tradition said that heat could not be successfully transmitted by 100% forced convection heating at temperatures above 1300° F. Lindberg Engineers, with the experience of designing several thousand Cyclone Tempering Furnaces, could see no logical reason for the heat limitation at that point. Twenty-one months ago they built a furnace to disprove it—the first Super-Cyclone. It was a success from the start . . . temperatures to 1750° F. with 100% forced convection heating, and equal heating and control accuracy throughout the range.

In blasting the "it-can't-be-done" tradition, the Lindberg Engineers are now able to offer you a furnace that increases production, keeps work straighter, and reduces handling. In addition, the Super-Cyclone generally requires but ⅓rd the floor space occupied by conventional equipment to handle the same or greatly increased production.

REPLACES 8 FURNACES

Typical of this is the Super-Cyclone shown above. A large midwestern appliance manufacturer was annealing grey iron castings in 8 radiation heated box type furnaces occupying an area 36′ x 9′. Now, one Super-Cyclone, requiring an area 6′ x 9′, *turns out twice as much work in 8 hours as all 8 furnaces had previously done in 16 hours!* One Super-Cyclone using but 1/6th the floor area, actually doubled the production of the 8 older furnaces. One Super-Cyclone's production is 12 times greater per unit of floor space than that of the 8 box type furnaces!

SUPER-CYCLONE

KEEPS WORK STRAIGHTER — reduces handling 83%!

The worm gears shown on the fixture, in the above photograph, are SAE 4140, weigh 20 lbs. each and have a maximum section of 3″. They are heat treated to 45 R.C. A load of 100 worms (2000 lbs.) is placed on the fixture, heated in a 38″ diameter x 60″ deep Super-Cyclone and quenched on the same fixture. The previous method was to heat in a radiation type box furnace with a hearth 36″ wide x 5′ deep, holding a maximum of 30 worms at one time. It took 3½ hours to heat the 30 worms in the box furnace. Time to heat the 100 worms in the Super-Cyclone is 4 hours.

The Super-Cyclone and the box furnace require the same floor area, 8′ x 11′. The box furnace turned out 8 gears per hour. The Super-Cyclone turns out 25 gears per hour . . . a production increase of 300%.

STRAIGHTNESS

In hardening the worms from the box furnace, 85% went out between .015″ and .025″. The high hardness of 45 R.C. made straightening extremely touchy. Straightening 100 worms required 8 hours. In hardening from the Super-Cyclone, *90% of the gears required no straightening whatsoever*, and the balance was out a maximum of .010″, easily taken care of in 30 minutes on the press . . . a reduction of 7½ hours straightening time per 100 gears.

HANDLING TIME

In handling 100 worms from the box furnace, 3 man-hours were required for loading, unloading, and quenching individually. In handling 100 worms from the Super-Cyclone, ½ man-hour is required for loading the fixture, quenching, and unloading. *Handling time is cut to 1/6th of what it previously had been!*

SUPER-CYCLONE

INCREASES PRODUCTION 670% — keeps rings round!

Above you see another example of the Super-Cyclone's ability to increase production, reduce handling, and minimize distortion with 100% forced convection heating. The illustration shows a load of 63, SAE 52100 bearing races on a fixture, being charged into a Super-Cyclone. When heated through, the rings will be quenched, fixture and all. When tested, they will be 62-65 R.C. and will be within .006″ to .010″ of round, the accepted range.

The previous method was to heat in a radiation type box furnace and quench individually on a special jig. This was done to hold the rings to .006″ to .010″ of round, which is now done in the Super-Cyclone . . . 63 at one time without jigs.

PRODUCTION INCREASED

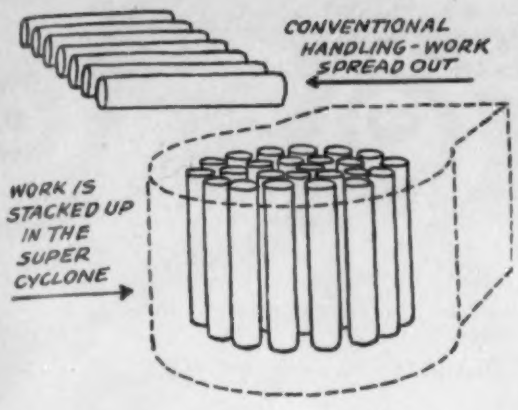
But let's compare the two methods of handling on an 8 hour day basis to give a clearer picture of the Super-Cyclone's ability in helping you to solve your heat treating problems. The box furnace turned out 64 rings per day. The Super-Cyclone turns out 432 rings per day, a production increase nearly 7 times greater than the box furnace. *It would take 7 box furnaces and 7 men to approximate the production of the one Super-Cyclone!*

HANDLING TIME REDUCED

The box furnace demanded the constant attention of one man, but the Super-Cyclone requires the services of a heat treater for only 1½ hours of the day, leaving 6½ hours in which he is free to do other work. In this one plant, Super-Cyclone production is nearly 7 times greater than the box furnace production and handling time is reduced 81%.

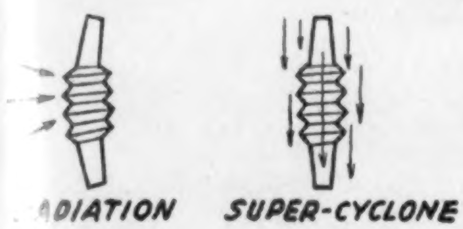
LINDBERG ENGINEERING COMPANY • 2451 WEST HUBBARD STREET • CHICAGO

LINDBERG FURNACES



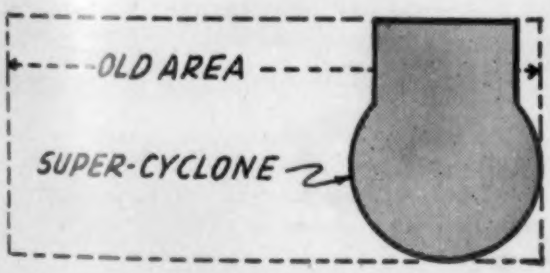
INCREASES PRODUCTION

You can roughly check the production increases possible in your shop through the Super-Cyclone by spreading an average load of parts on the floor, one layer thick, as laid out in a radiation heated furnace. Now, take another load of those same parts and stack them up in a 36" diameter circle, 4' high, making allowance for spacers and supports. Figure it will take a maximum of 3 hours to heat the load and 5 minutes to quench. Ordinarily you will find production increases of 200% to 1000% possible.



KEEPS WORK STRAIGHTER

The 100% forced convection heating principle of the Super-Cyclone means that the work is heated uniformly and accurately by air, driven at high velocity through the charge. The heat source is confined to a separate chamber, away from the work, to prevent radiant heat, of a source hotter than the desired work temperature, from striking the charge and causing distortion. Thus straightening time is eliminated or reduced to a fraction of what is required from conventional equipment and the man-hours previously required for straightening are now available for other work.



LESS FLOOR SPACE

As a conservative thumb rule, you can figure that the Super-Cyclone will require not more than ⅓rd the floor space required by any other equipment to handle the same or greatly increased production. This rule is general, of course, and may not fit all cases. It is based on averages of what the Super-Cyclone has done in other plants. A Lindberg Representative can give you, quickly and accurately, any production figures, floor space layouts, or other information you may need.

STANDARD SIZES IN WHICH THE SUPER-CYCLONE IS AVAILABLE

Delivery time is speeded considerably when standard size furnaces are selected, rather than special sizes which must be drawn up. Drawings are available for the following sizes of Super-Cyclones all of which have been built and are in operation. Most are gas fired, although a number are available electrically heated.

CHAMBER SIZE
16" diameter x 20" deep
22" diameter x 26" deep
22" diameter x 36" deep
25" diameter x 20" deep
25" diameter x 30" deep
25" diameter x 48" deep
28" diameter x 28" deep
28" diameter x 48" deep
28" diameter x 60" deep
33" diameter x 36" deep
33" diameter x 48" deep
38" diameter x 36" deep
38" diameter x 48" deep
38" diameter x 60" deep
43" diameter x 48" deep
48" diameter x 72" deep
60" diameter x 36" deep
60" diameter x 48" deep
60" diameter x 72" deep

SUPER-CYCLONE QUENCHING

When the first Super-Cyclone was being designed, Lindberg Engineers anticipated the obvious problem of mass quenching of heavy loads and devised equipment to take care of the situation. A typical example is the 2000 lb. load of worm gears shown on the opposite page, which is heated and quenched, fixture and all. Jobs similar to this are being quenched, with perfect results, every day in plants all over the country.

Heat treaters who have seen the Super-Cyclone in action, quickly appreciate that to secure all the advantages of which the furnace is capable, the quench must be looked at from an entirely new standpoint. This involves quench tank size, oil velocity, volume of oil, cooling and storage.

Twenty-one months of production experience in our own plant and in the field, with over 100 installations, have enabled Lindberg Engineers to work out an accurate formula which greatly simplifies this problem.

SUPER-CYCLONE HAS WIDE RANGE OF USES

THE TEMPERATURE RANGE of the Super-Cyclone is 250° F. to 1750° F. with equal heating and control accuracy throughout the entire range. Thus it is a highly flexible unit for the small or medium heat treating department, as well as a heavy production unit for the large shop when put to work on one type of job.

Among the operations being handled by over 100 Super-Cyclones already in service are the following:

HARDENING: Typical of the Super-Cyclone's ability to turn out heavy production of touchy parts are the examples shown on the opposite page.

ANNEALING: A large Wisconsin foundry is annealing and normalizing loads averaging 5,000 lbs. One Super-Cyclone 60" diameter x 48" deep turns out 17½ tons of work per day.

NORMALIZING: Because work can be stacked up densely, and quickly heated, The Super-Cyclone is an ideal furnace for normalizing.

TEMPERING: The Cyclone Principle of heating is well known to heat treaters for extremely accurate tempering under heavy production conditions. You can temper in the same furnace that you harden in with perfect heating accuracy for both operations.

NITRIDING: The Super-Cyclone fitted with a retort and cover does the same uniform job of nitriding as the standard Cyclone Nitriding Furnace. In addition, the temperature range of the Super-Cyclone enables the retort to be "cured" without removing from the furnace.

SPECIAL HEATING: Because work can be preheated at any desired rate—and cooled according to a definite schedule, the Super-Cyclone is well suited to stress relieving, spheroidizing, malleablizing and other heating operations requiring a specific cycle.

OVER 100 SUPER-CYCLONES ALREADY IN SERVICE

IMPORTANT NOTE: Like all other Lindberg developments, the Super-Cyclone has been thoroughly proved under 24-hour a day production conditions for a minimum of 12-months before announcement to the trade. Every effort has been made to restrict the sale of these units until the probationary period was completed. In spite of this, however, many of those who have seen the furnace in operation during the past 18-months have quickly been aware of its production possibilities and requested that units be constructed for them. Thus, over 100 Super-Cyclone installations are in service from coast to coast. One or more of these is near you, as is a Lindberg District Office, staffed by practical and competent sales engineers. The Super-Cyclone is *not* a cure all, nor do we represent it as such. It is speeding production, turning out straighter work, and cutting costs for many firms however, and we will be glad to survey its possibilities for you, on your work, at your request.

SUPER-CYCLONE FOR ANNEALING, NORMALIZING, HARDENING, AND TEMPERING

HYDRYZING FOR SCALE-FREE AND DECARB-FREE HARDENING

CYCLONE FOR LOW-COST ACCURATE TEMPERING

bath. With gear and clutch parts of oil hardening steels, the areas may be heated with a torch to the required surface temperature, then the part removed and quenched in a separate oil tank.

Block tips can be machined to fit contours. To avoid overheating edges, it may be necessary to plug the outer orifices or to elevate the tip on the edges. Holes are sometimes filled with carbon or asbestos or a mixture of both to obtain uniform hardness without overheating. If a large section is next to a thin section being hardened, auxiliary heating flames may be needed to keep the large section from withdrawing too much heat.

Light machine parts of steels such as S.A.E. 1010 are often carburized to a depth of several thousandths of an inch with an excess acetylene flame before flame hardening. (J. G. Magrath of Air Reduction in *Am. Machinist,* Vol. 86, Feb. 5, 1942, pp. 54-57; Feb. 19, 1942, pp. 107-109; Mar. 5, 1942, pp. 178-180; Mar. 19, 1942, pp. 217-219. For previous installments see METALS AND ALLOYS for April, 1942, p. 656.)

Machinability of Cast Iron, Steel

Condensed from *Machinery (N. Y.)*

The Brinell test is a very useful simple measure of machinability, except in minor cases (such as austenitic steels) where work hardening affects the machinability more than ordinary hardness does. Simple file or drill tests can also be used.

Malleable castings with under 0.2% C have the best machinability, with carbon steel and gray iron castings next, mottled cast iron, and finally white cast iron with the lowest machinability. Good machinability of cast iron is due to the lubricating effect of graphitic carbon; brittleness (which allows the chip to break off), and lack of high strength, with resultant low power consumption.

In cast iron, silicon promotes machinability up to 2.75% but causes a decided drop over 3%. Manganese in the usual ranges has little effect. Sulphur up to about 0.14% has little adverse effect if sufficient manganese to form manganese sulphide is present. Effect of phosphorus is controversial.

Graphitic carbon promotes machinability, but the size and form of graphite are important. Machinability of gray iron is inversely proportional to the combined carbon. However, modern high strength castings are readily machinable in spite of 0.6-0.8% combined C.

Nickel up to about 2% is beneficial. Chromium has little effect until carbides appear in the microstructure. Molybdenum has no effect up to about 0.5%, but higher percentages decrease the machinability. Copper is similar to nickel but to a lesser degree.

Zirconium up to 0.15% increases machinability. Titanium is similar to zirconium. Vanadium is similar to chromium.

Annealing at 1400°-1500° F. improves machinability at the expense of strength. Improper processing may lead to a thin surface layer of white iron with deleterious effect on the machinability. The first cut is often heavy to cut under any possible layer of fused-on molding sand. Austenitic castings may give trouble if they have been work-hardened by tumbling, etc.

Steel castings require more power for machining than cast iron and also have a tendency to build up on the cutting tools. Selenium and sulphur in amounts up to 0.3% improve machinability. Columbium fixes carbon in stainless steel and is stated to have a beneficial effect on machinability.

When manganese and sulphur are both on the high side, the manganese sulphide has a beneficial effect. Zirconium promotes machinability, probably by slagging off abrasive particles. Bismuth improves machinability of stainless steels with no detrimental effects [see METALS AND ALLOYS, Vol. 14, Aug. 1941, p. 241].

Deoxidizers have a marked effect on machinability as shown in tests on free-machining steels [*no details of analysis or test methods are given*]:

machinabiltiy rating	*turning operations*	*drilling operations*
1	Mn	Mn
2	Cr	Cr
3	Si	V
4	Zr	Zr
5	Al	Ti
6	V	Si
7	Ti	Al

Hardness of steel castings generally but not always is an indication of machinability. As with cast iron, fused molding sand on the surface may cause trouble.

Malleable castings are the most machinable type of ferrous castings, owing to their structure of ferrite and tempered carbon. Machinability is usually proportional to the amount of carbon present, and production work has shown that maximum machinability of this type is obtained with a tensile strength of about 50,000 lbs./in.² and an elongation in 2 in. of 7%.

A small proportion of pearlite gives excellent machinability with a very smooth finish. (E. K. Smith of Electro Metallurgical Co. in *Machinery (N. Y.)*, Feb. 1942, pp. 129-131; Mar. 1942, pp. 131-133.)

Brass Plating

Condensed from *Transactions,* Electrochemical Society

Brass is plated for the purpose of matching the appearance of solid brass or bronze, and to obtain adhesion of rubber to metal (steel). Brass plating for the latter purpose may be expected to increase and of the former to sharply decrease during the emergency.

All commercial brass baths are cyanide solutions. The following bath is recommended for "rubber bonding" purposes:

Copper cyanide, $CuCN$—3.5 oz./gal.
Zinc cyanide, $Zn(CN)_2$—1.5 oz./gal.
Total Sodium cyanide, $NaCN$—6 oz./gal.

This bath is operated between 80° and 95° F., with a current density of 9 amps./ft.². The pH should be between 10.3 and 11.0, measured colorimetrically.

Brass anodes of 75% Cu and 25 Zn are used. Anode and cathode efficiencies are about 75%. Brass containing from 18 to 40% Zn may be readily deposited from

this bath by varying the temperature or current density.

Addition agents or addition salts are sometimes added to brass baths, but are not essential. Tartrate, citrate, arsenate, phenol, etc. are sometimes used to permit more rapid deposition, or to control the composition of the deposited brass.

The bath temperature may be varied to produce the composition or color of deposit desired. An increase in temperature of 5° F. causes a 3% decrease in zinc content of the deposit.

Control of the pH of brass baths is important. For pH measurements, indicators (sulpho orange or nitro yellow), the "Type E" glass electrode, or pH papers may be used. Increasing the pH increases the percentage of zinc in the deposit.

Sodium or ammonium hydroxide is added to raise the pH and sodium bicarbonate to lower it. The use of acid salts such as sodium bisulphite or weak acids such as boric acid in place of sodium bicarbonate is not recommended, because of the danger of evolution of hydrogen cyanide.

The covering power and throwing power of brass cyanide solutions is high. However, in remote areas and recesses, the brass may be pink due to high zinc content. A cadmium strike on gray and malleable cast iron is recommended, followed by brass plating. It is difficult, but possible, to plate brass directly onto aluminum and stainless steel.

Control of brass baths is not difficult. Sodium carbonate removal is usually unnecessary. Addition of about 5 lbs. of sodium cyanide is recommended for each 1000 ft.² of work plated. The only other additions necessary are those required to adjust the pH.

Analysis of solutions, specifications for anodes, and testing of deposits are discussed. (H. P. Coats of Firestone Tire & Rubber Co. in *Trans. Electrochem. Soc.*, Vol. 80, 1941; Preprint No. 37, 11 pp.)

Cleaning, Finishing Magnesium

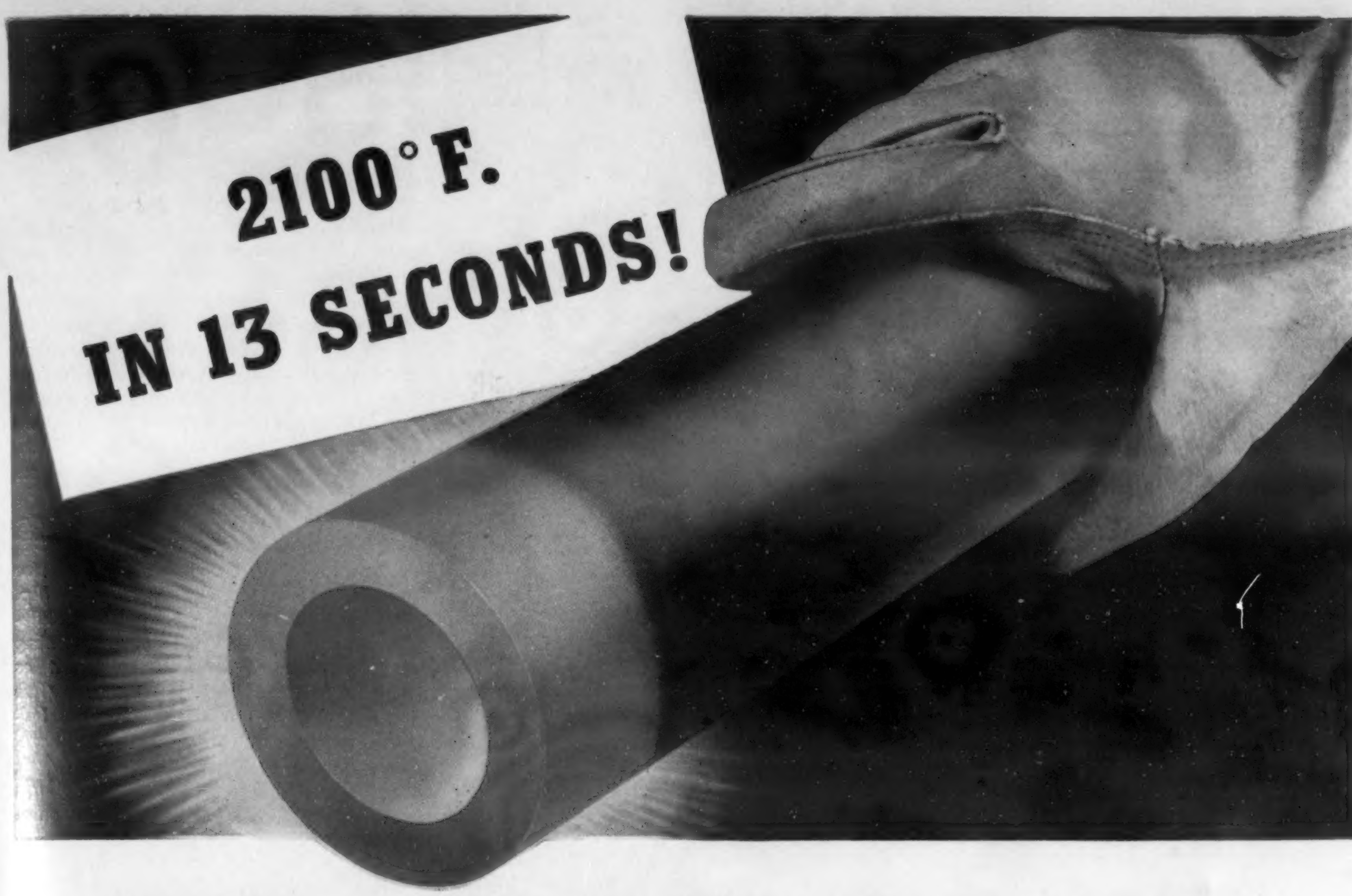
Condensed from *Metal Finishing*

The cleaning procedures recommended are much the same as those used for other metals. The cleaning cycle consists of solvent-vapor or emulsion degreasing, followed by cathodic electrocleaning or by cleaning in a boiling alkaline cleaner.

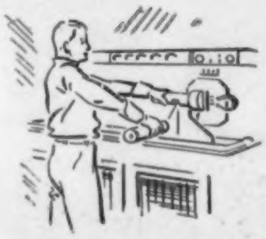
Some alloys retain a gray oxide film after the above cleaning procedure. This is removed with a nitric-sulphuric acid dip, a chromic acid dip, or by sanding.

Following the above cleaning procedures, the magnesium alloy is given a treatment which forms a durable, adherent surface film. This film improves paint adherence and durability and retards corrosion. A variety of procedures for carrying out this step are available. Four of these are described in this article.

The first, or "Dow #1" treatment, consists of "chrome-pickling," by dipping the work ½ to 2 min. in a sodium dichromate-nitric acid solution, followed by rinsing in cold and hot water. This solution removes some metal and passivates the surface.



TOCCO heats shell forgings so fast they can be handled without tongs!



Another vital armament job being speeded and improved by TOCCO Induction Heat Treating:

Here, TOCCO heats the open end of shell forgings—to 2100 degrees F. in 13 seconds—so fast the shell body remains cool and can be handled to the nosing press without tongs. Heat is localized in section to be forged.

Boosts output. Compared to former method, TOCCO speeds up heating and handling. Reduces hazards.

Minimizes scale formation. Increases die life.

Improves operation. TOCCO controls the heating period to 1/10 second, automatically. Assures uniform temperature and uniform length of heated zone.

Machine is clean and cool. Occupies space only 7 ft. x 5 ft. maximum. Pre-set controls. Simple push-button operation; doesn't require skilled labor.

TOCCO is a standard unit. Can be adapted to post-war jobs by simply changing work fixture.

Investigate TOCCO today for speeding up and improving your hardening and heating!

THE OHIO CRANKSHAFT COMPANY
CLEVELAND, OHIO

SPEEDY ELECTRIC HEAT IS GENERATED WITHIN THE SECTION TO BE HEAT-TREATED

Brass or steel inserts must be stopped off. Additional corrosion resistance is obtained, especially on die castings, by boiling the chrome-pickled parts 30 min. in a solution of 1 to 2 lbs./gal. of sodium, potassium, or ammonium dichromate.

The second (and the most popular) treatment is known as the "acid-dichromate" or "Dow #7" treatment. This and the following treatments do not affect the dimensions of the work. The first step of this treatment consists of a 5 min. dip in a solution of 15% to 20% by weight of hydrofluoric acid at room temperature. This dip is followed by a cold water rinse, then by 45 min. boiling in a 10% sodium dichromate solution. A subsequent 5 min. dip in tung oil at 302° F. is sometimes used as a sealing coat.

The third treatment described is known as the "alkaline-dichromate," or "Dow #8" treatment. This treatment requires two steps following the hydrofluoric acid dip.

The fourth treatment consists of anodizing. Following thorough electrocleaning and rinsing, the work is electrolyzed as anode for 30 min. at 5 to 10 amps./ft.^{2}, rinsed, and then dried. This may be followed by the above tung oil treatment. The anodizing bath contains 10.8 oz./gal. of chromic acid, 4.1 oz./gal. of phosphoric acid, and 7.5 oz./gal. of 29% ammonia. It is operated at 122° F.

This type of work should replace some business lost by platers as a result of the present emergency, since platers are familiar with, and equipped for, the operations involved. (James P. ApRoberts of Turco Products, Inc. in *Metal Finishing*, Vol. 40, Feb. 1942, pp. 84-87.)

Rectifiers and Electro-Cleaning

Condensed from *Products Finishing*

The development of cleaners especially adapted to anodic, or reverse current cleaning, has led to an increase in the use of this method of cleaning. For cleaning steel parts, anodic current densities as high as 80 to 100 amps./ft.^{2} may be used. In the case of soft, non-ferrous metals, reverse current cleaning must be employed with caution because of the tendency of the metal to discolor. The best practice in cleaning non-ferrous materials is to pre-clean with a degreaser, a solvent emulsion, or a direct-current cleaner, followed by a very limited time in a reverse current cleaner.

No cleaner compound is capable of giving the highest efficiency as both an anodic and cathodic cleaner. Therefore, rather than use a single tank equipped with a reversing switch, it is advisable to use 2 tanks, one for anodic and one for cathodic cleaning.

Since 2 tanks, thus connected, are at opposite potential, they are a troublesome source of shorts and stray currents. If the steel tanks themselves serve as electrodes and if they are fed from the same bus bars, there is the possibility of a disastrous short through the steel of the building or through various heating and cooling pipes.

The use of rectifiers is ideal in this situation, since each tank can be fed from

For thick-skinned HELL BUGGIES!

"AW-3" (ARMOR WELD)

Developed in collaboration with the leading authorities on armor plate, "AW-3" is a shielded arc electrode for fabricating cast, rolled homogeneous, and face hardened armor plate. Used also for repairing cast armor plate at room temperatures.

It's an austenitic modified 18-8 electrode with 308 base for all-position welding. Has an ultimate strength of from 85,000 to 87,000 pounds per sq. in. Available in sizes from 3/32" to 1/4".

General Offices: 4550 West National Avenue, Milwaukee, Wisconsin

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provide accurate current control with but one simple adjustment. The unique square frame design enables you to stack machines one above the other for single or parallel hook-up to meet every welding need. Write for bulletin W-28.

a separate rectifier, or each from a separate bridge of the same rectifier. Stray currents and the possibility of shorting are thus eliminated. This makes unnecessary the installation, maintenance and repair of insulation between the tanks. (Harold Leever, of MacDermid, Inc., & John C. Bogle, of Udylite Corp., in *Products Finishing*, Vol. 6, Jan. 1942, pp. 10-18.)

Splatter and Fluidity in Welding

Condensed from *Welding Journal*

The fusibility tests described have a variety of purposes, but the principal object of the tests is to determine the ability of the rod or electrode to melt quietly, and to have suitable fluidity to produce a sound weld in whatever position it is desired to conduct the welding application.

Soundness of the weld is not only a function of the welding quality of the electrode, but also of the base metal, since blowholes may originate in the weld from gas generated in the arc, reactions in the melt with oxides, sulphides or other inclusions from any source. Blowholes are more prevalent in metallic arc welds owing to the more rapid rate of freezing than in gas welds.

Excessive arc length in welding produces deposits having frequent blowholes; reduced welding speed and suitable coating favor sound welds. On the other hand, reactions in the melt causing bubbling favor the production of concave fillet welds, may remove other dissolved gases, aid in separating slag from weld metal and refine the grain structure. The external appearance of the weld is affected unfavorably by bubbling, as is operator comfort; blowhole formation is prevalent under bubbling conditions.

The tendency of an electrode to spatter has not as yet been tied down to any one factor, but methods for minimizing spatter have been successfully applied. Excessive currents or improper polarity are major sources of spatter in welding. Coating constituents have an important affect in stabilizing the arc, and reducing spatter loss.

The external appearance of a weld is judged on the basis of uniformity and smoothness and contour of the bead cross section. Freedom from undercut, excessive rippling and reinforcement are factors in the attainment of high fatigue strength.

Coatings have a pronounced effect on bead contour; in general the heavier and more fusible the coating, the more concave is the bead. As the fluidity of weld metal increases, the bead becomes less convex and increasingly concave.

Lack of fusion at the root of arc and gas welds is the most common defect, and is due to initially cold base metal, which is not liquefied and caused to merge with the weld metal. Chipping out the root area in arc welds is considered to be essential to maximum service life of welded joint.

Among the other factors responsible for lack of root penetration are films of slag on base metal, too large an electrode, long arc and inadequate current. (W. Sparagen & G. Claussen, *Welding J.*, Vol. 21, Feb., 1942, pp. 65s-85s; a correlated abstract of 250 references.)

Hot-Quenching High-Speed Steel

Condensed from *Mechanical Engineering*

Approximately 3% is added each year to the manufacturing costs of high-speed tools because of crackage during hardening. In this investigation an effort was made to eliminate crackage stresses by decreasing the differential existing between the hardening temperature and the temperature of the quench—in other words, by "hot-quenching."

High-speed steels have the unique characteristic of retaining their hardness even at a dull-red temperature. This hardness is attributed to martensite, with abrasion resistance added to the structure by the complex alloy carbides present in the matrix. Certain elements (tungsten and molybdenum in particular) impart stability to the martensite, thus preventing its softening at normal operating temperatures.

At the hardening temperature of 2350° F. (slightly below the point of incipient fusion), the structure of 18-4-1 high-speed steel consists of an austenitic matrix, containing carbon, tungsten, chromium and vanadium. In addition to these alloys, certain complex carbides of the elements are present that do not go into solution at the elevated temperature. Upon quenching the steel, the resulting composition is made up of high-alloy-retained austenite, high-

alloy martensite, and the undissolved alloy carbides.

Austenite is non-magnetic in nature. Martensite, a decomposition product of austenite, is magnetic in nature. This property, therefore, suggests the use of a magnetic analysis in following the austenitic transformation on hot-quenching. With this principle in mind, an electric furnace was constructed, containing a magnetic circuit for following this change.

The specimens used in the magnetic part of the study were $\frac{1}{4}$x$\frac{3}{4}$x$\frac{3}{4}$ in. pieces of 18-4-1 high-speed steel. Because of their low heat conductivity, they were preheated at 1650° F. for half an hour. This treatment corresponds to commercial practice.

After the required soaking, the specimens were transferred to the high-heat furnace held at 2350° F. This furnace was of the "Globar" type equipped with a diamond block to reduce harmful oxidation. After $2\frac{1}{4}$ min. at the hardening temperature, the specimens were quenched in a molten bath.

Those specimens quenched above 625° F. were quenched in a lead bath. Pieces quenched below the melting point of lead were immersed in a ternary alloy composed of lead, tin and calcium. The test specimens were quenched for 15 sec. and immediately transferred to the magnetic furnace, which was operating the temperature of the quench.

The specimens were held at the quench temperature for one hour in the magnetic furnace, and then permitted to furnace-cool. Readings of primary current were made frequently during the period at quenching temperature, and every 20° F. on cooling. No change in magnetism was noted at the temperature of the quench, which indicated that no isothermal decomposition of austenite took place during the hour held at that temperature. (Cohen and Koh have observed that isothermal transformation of retained austenite at 1150° F. requires about 5 hrs. to begin.)

The magnetic-change results for low-quench temperatures (300°-400° F.) indicate that the maximum transformation occurs at 310° F., with most of the transformation occurring over a 100° F. range. For the 700° F. quench, the temperature of greatest austenite decomposition was 320° F. and for the 900° F. quench it was 330° F., with some transformation occurring over the entire cooling range.

However, quenching to such temperatures as 1050° and 1150° F. induces a somewhat different transformation behavior. Instead of *one* point, these quenches exhibit *three* points of magnetic (and, therefore, constitutional) change. For the 1050° F. quench, these were 550°, 470° and 350° F. For the 1150° F. quench, they were 610°, 550° and 490° F. Special tests with a 975° F quench showed that the line of demarkation beetween the 2 types of transformation behavior lies somewhere between 975° and 1050° F.

Increasing the quenching temperature up to 900° F. reduces the hot-quenched hardness and increases the toughness. However, cracks were prevalent in the test specimens quenched at and below 975° F.

On the other hand, specimens quenched to temperatures above 975° F. were found to be free of cracks. The as-quenched hardnesses of pieces quenched at 1050° and 1150° were 64.6 and 64.4 Rockwell "C", respectively—probably the result of "precipitation hardening" effects.

To determine the practical aspects of hot-quenching methods, a series of lathe breakdown tests and Charpy impact tests were conducted. Also specimens for the physical tests were subjected to a commercial 2-hr. temper at 1050° F.

Based on the lathe tests, a trend toward a slight decrease in tool life with an increase in quenching temperature was noted. Investigation of the unnotched Charpy specimens indicated an increase in impact strength with an increase in quenching temperature. The conclusions of the impact tests are in complete agreement with the magnetic and hardness studies.

Hardness and impact resistance are both desirable qualities in a cutting tool. Impact resistance is particularly important under intermittent cutting conditions. Since the tool life resulting from the hot quenches investigated seems to be practically constant, toughness is suggested as the proper criterion for judging such treatments.

Apparently, therefore, the 1050° and 1150° F. quenches are better for lathe tools. (Robert Hughes McCarthy in *Mechanical Engineering,* Vol. 64, Mar. 1942, pp. 201-204.

Substitute Solders and Their Use

Condensed from a report of the Advisory Committee on Metals and Minerals, National Research Council, National Academy of Sciences

The tin situation becomes increasingly acute, with the Far East supplies cut off and the projected domestic smelter and national salvage system not yet in full operation. This report to the WPB, prepared by H. W. Gillett of Battelle Memorial Institute [and METALS AND ALLOYS' *editorial director] brings up-to-date a similar report made in July 1941 (see* METALS AND ALLOYS, *Aug. 1941, p. 187), and takes full account of drastically changed supply conditions and of new substitutes.*

—The Editors.

In 1941 it is reported that 48,700 tons of tin went into tin plate, and 18,420 tons of new tin went into solder. Solder made with new tin is estimated as containing an average of 36.4% Sn during 1941. Figures for secondary tin in solder for 1941 are not yet available. In normal times, solder has accounted for over 20% of the total tin consumption, with tin plate accounting for around 50%.

Solders for Cans

The situation has changed since June 1941. Automobile production for civilian use has been stopped; the use of tin-containing body solder for repair work has been banned, which leaves the can-making industry as the largest remaining user of solder. Because can-making is done at such a high rate—350-400/min.—the automatic soldering of the side seam of a food can is about the most difficult soldering task that is attempted. Obviously, a solder that will accomplish this task will accomplish almost any other task of soldering.

Major changes in the type of material used in cans are on the way. The comparatively heavy hot-dipped tin coatings formerly used will be replaced by much thinner electrolytic tin coatings as soon as the electrolytic production lines, being installed by practically every steel maker who makes can stock, come into operation.

Also, improvements in lacquer coatings over tin-free "black plate" that has been given a "bonderizing" or analogous coating at the mill, are rapidly extending the range of applicability of tin-free stocks to cans for food products that had to be packed in tin before the lacquers were sufficiently perfected. The steel mills are installing production lines for the "bonderizing" and analogous processes.

The can-maker, thus, has to solder at present 3 types of can bodies: (1) those made from hot-dipped plate; (2) those from electrolytic plate; and (3) those from black plate. Ultimately, the last 2 classes will become the preponderant ones. That is, something is being done about reduction of tin on *cans*. Something must now be done, and very promptly, about the substitution of tin-free for tin-containing *solder*.

Substitute Solders

As stated in the July 1941 report, it was then apparent from some preliminary experiments that a lead-silver solder, about 97.5% Pb and 2.5 Ag, could in an emergency be used for can soldering. Similar solders—97.25% Pb, 2.5 Ag and 0.24 Cu for electrical equipment, and 95% Pb and 5 Ag for radiator dipping—had long been in use where operating temperatures were too high for lead-tin solders.

The lead-silver solder has a higher melting point than lead-tin solder, so it requires a higher temperature of application. In the hope of avoiding even this small difference in technique or application, several substitute, low-melting solders have been tried out. One of the best of these (and one alleged to be the favorite German substitute) is 90% Pb, 8 Cd and 2 Zn, or slight modifications thereof. This resembles lead-tin in ease of application and makes good joints.

However, the supply of cadmium is limited, as it is obtained solely as a by-product of zinc production. Navy requirements for cadmium plating leave little for other uses, so it would be necessary to shift to zinc plating (which is almost always a usable substitute, and indeed, is preferable for many applications) before enough cadmium could be released to affect the solder situation.

Other suggestions have been for bismuth-

containing solders, such as 80% Pb, 15 Bi and 5 Sb, and for "intermediate" solders containing a smaller tin content than lead-tin solder, with some tin replaced by silver and with bismuth added to pull down the melting point. None of these appears satisfactory for soldering side seams of can bodies. In spite of a fairly good appearance to the eye and satisfactory bursting tests (which measure the locking effect of the seam more than the strength of the soldered joint), joints made with these solders proved to be imperfect through "hot brittleness"—the solder joint pulled itself apart, into 2 layers, on freezing.

The use of *any* tin in a substitute solder during a period of transition to an entirely tin-free solder is merely "cutting off the dog's tail by inches." When a new technique has to be developed and equipment modified, it is better to go directly to what will finally have to be used.

Under other soldering requirements than those of can-soldering, where pressure could be kept on the joint as it freezes, or where the joint could be rapidly chilled, or where some splitting of the joint can be tolerated, these long-freezing-range substitute solders may have application. There may be cases where the metal to be joined will not stand the higher temperature at which the lead-silver solder must be applied, in which the faults of the long-freezing-range solders may have to be put up with, or overcome.

The Lead-Silver Solders

For many purposes, the 97.5% Pb, 2.5 Ag solder appears the most suitable composition. Slight reduction of silver, with the introduction of a little antimony and perhaps a trace of phosphorus has been suggested, but, while usable for some purposes, does not appear to fill the joint in can soldering as well as the straight lead-silver.

A composition long used in the electrical industry has been 97.25% Pb, 2.5 Ag, 0.25 Cu, and may be an improvement for soldering copper. Addition of either copper or antimony appears detrimental (or at least not desirable) for soldering tinned surfaces, on the information so far at hand.

The 97.5% Pb, 2.5 Ag composition is close to the eutectic, and the solder freezes sharply at its melting point, without a freezing range. To produce a slight freezing range, the silver may be raised to 5 or 6%, as specified in S.A.E. Aircraft Materials Specification 4755 for dipping solder. Increase in silver increases the strength of the joint, but latest information is that increase above 4% Ag will seldom, if ever, be justified.

Once the technique of applying lead-silver solder is understood and adopted, its cheapness and availability bid fair to make it the standard material, so that the term "solder" is likely to come to mean this alloy rather than lead-tin. Properly made lead-silver joints are stronger than those of lead-tin. In appearance, the lead-silver solder is dark, like lead, rather than bright, like tin or lead-tin solder. But appearance is not important today.

Soldering Technique With Lead-Silver

Beside the higher melting point (about 580° F.) and the higher temperature of application (say 675°-775° F.) for lead-silver, the lead-silver solder requires active fluxing. Rosin is not satisfactory, and the organic amines that are effective non-corrosive fluxes for lead-tin and lead-cadmium-zinc solders are too strongly decomposed at the necessary temperature.

Zinc chloride is an effective flux, and particularly so when, as in dip soldering, it can be conveniently used in the fused condition, as a layer over the molten solder. Since zinc chloride leaves residues that are difficultly soluble in water, washing the flux from the finished joint is done with dilute hydrochloric acid, followed in turn by water, dilute sodium carbonate and water.

The solder itself, as well as the metal to be soldered, must have a clean surface. A useful means of avoiding surface oxidation has been developed by General Electric engineers, involving the use of hydrogen-containing fuel gas for heating the joint. [*This practice was described in a "Shop Note" in our April issue, p. 635.*—The Editors.]

In soldering side seams of cans, it is important that the seam be wiped practically free from excess solder, for if good wiping is not done, the too-thick layer may cause failure in double-seaming. To allow wiping, auxiliary gas-flames, using hydrogen-containing gas, are played on the can body just adjacent to the seam. This

change in technique is necessary because of the lack of freezing-range to give time for wiping under normal cooling.

A practical question in can-making is whether the lead-silver solder bath will pick up so much tin from tinned can-bodies passing through it as to become hot-short, after the fashion of the "intermediate" lead-tin-silver solders. The indications are, however, that the tolerance for tin will be sufficient so that the build-up of tin will not be troublesome.

Application on Substitute Can Materials

Experimental operation of lead-silver solder on hot-dipped plate with proper temperature control, fluxing, and auxiliary heating for wiping have progressed far enough to warrant the assumption that, once the technique is understood and the necessary equipment changes made, ***no tin whatsoever*** need be used in the initial solder for side seams of cans and that the rate of production need not be materially decreased. End-soldering of cans with lead-silver brings in very little difficulty.

Less complete evidence is so far available as to behavior of lead-silver in soldering cans made from thin electrolytic plate. However, there is little doubt in the minds of those working on this, that by the time electrolytic plate is available in quantity, the problem of soldering it with lead-silver solder will have been satisfactorily solved. As far as can be told at present, an electrolytic plate that will be satisfactorily solderable with lead-tin will also be solderable with lead-silver.

The situation is not so far advanced on the soldering of untinned, black or "bonderized" material. Soldering these with lead-silver cannot yet be classified as commercially feasible, though there is no inherent reason why it cannot be worked out, by proper attention to such features as mechanical cleaning, active fluxing, deposition on the parts to be joined of a solderable coating such as silver, etc.

Active study of soldering black plate is urgently needed. Welding would give a complete answer to the problem save that welding methods are not yet developed to give the speed can-makers are accustomed to, and will require extensive modifications of equipment.

Pending the solution of this problem, it will be more practical to permit use of lead-tin solder for making cans from black plate than to forbid it, because the amount of tin in the lead-tin soldered seam is much less than that on the can body, even when made from very thinly coated electrolytic plate.

Corrosion and Toxicity

Confining attention for the moment to the matter of making hot-dipped or electrolytic tin plate into cans by lead-silver soldering, with suitable technique for making a mechanically good joint, certain questions arise as to corrosion of the outside of the seam, and to corrosion and toxicity on the inside. Under ordinary conditions the lead-silver solder appears to be a corrosion-resistant material. Under unusual conditions, it may corrode, for the presence of the silver may set up an electrolytic couple, in the presence of moisture or in contact with some organic materials, these high-lead alloys may be subject to chemical attack.

Greenwood and co-workers reported attack on lead-silver alloys, containing 0.1-28.4% Ag during storage in a laboratory cupboard for 1.5-3 yrs. Since such a statement is both disturbing and out of line with the use of lead-silver solder in mine motors since 1927, inquiries were made to the various laboratories with most experience with the lead-silver solders.

One laboratory has alloys of 25% Ag, 75 Pb; 10% Ag, 10 Cu, 80 Pb; 20% Ag, 10 Cu, 70 Pb that have been stored since 1927, and 2.5% Ag, 0.25 Cu, 97.25 Pb since 1931, with no signs of disintegration or attack other than a dark surface tarnish. Also, lead containing something under 1% Ag is used for anodes in electrolytic zinc manufacture because of its great resistance to corrosion.

The question of toxicity has been discussed with the Food Division, Food and Drug Administration, with can-makers and other experts. It appears that the side seam is so thoroughly closed in modern can-making practice that actual contact of solder with contents, even at the ends where the seam is trimmed down, is of extremely small area.

In cans with floated ends, a type largely superseded by the "sanitary" can, more con-

tact is possible. Cans for evaporated and condensed milk, even of the sanitary type, may be filled through an opening that is finally plugged with a drop of solder. Canned milk is, however, said not to attack lead alloys in general.

In either the ordinary sanitary can or the sanitary type milk can soldered with lead-tin solder, experience has shown no toxic effects from the seam or the plug, but such effects have been feared from drops of solder that might spatter in during wiping of the side seam or fall off of the plug during sealing. Spatter is, therefore, to be carefully guarded against, and to make assurance doubly sure, the lead-silver solder seam and its trimmed ends, are to be lacquer-coated on the inside after soldering. [*The problem of toxicity is undergoing further investigation.*—Editors.]

Dip Soldering

Since a lion's share of the present requirements for solder is in cans, can soldering has been discussed first. Another major use is in the dip soldering of radiators, oil coolers, and the like for trucks, jeeps, aircraft, etc. These bring in questions not only of bonding and joint strength, but also of corrosion—especially "galvanic" attack.

When equipment is available for so-called hydrogen-copper brazing (which includes the use of other reducing atmospheres as well as pure hydrogen, and of brass as well as copper), joining steel with copper and copper with brass by such means instead of soldering, deserves careful consideration. When the temperatures necessary for such brazing methods are out of the question, but that of around 850° F., as used with the 95% Pb, 5 Ag and the 97.5% Pb, 2.5 Ag solders, is applicable, the lead-silver solders, when used under a flux layer of fused anhydrous zinc chloride, give good results as dip solders.

The zinc chloride must be removed from the finished article, and as previously stated, this removal should be with an acid wash, such as 1 or 2% hydrochloric acid, because washing with water alone produces oxy-salts that are relatively insoluble in water and remain on the work to produce corrosion troubles later. After the acid wash and a water rinse, another wash with dilute sodium carbonate to neutralize the last traces of acid, is required.

General Conclusion

So much evidence is at hand that, by suitable technique, tin-free solder can be used in place of tin-containing solder that the use of tin-free solder should promptly be made the rule rather than the exception. The burden of proof lies heavily on any solder-user that claims he must persist in eating into our stock pile of tin to show that his alleged inability to get along without tin results from real engineering requirements of his particular use of solder rather than from unwillingness to learn the suitable technique for use of tin-free solder. (H. W. Gillett in a *National Academy of Sciences* Report to the WPB, Mar. 26, 1942, 13 mimeographed pp.)

Grinding of Tools

Condensed from *Machinery (London)*

Grinding cracks usually indicate too hard a grinding wheel or too much grinding wheel or too much pressure. It is sometimes difficult to distinguish between a fine network of grinding cracks and cracks formed during heat treatment; however, grinding cracks are usually perpendicular to the traverse marks of the grinding wheel and often are concentrated at the edges, while heat treatment cracks are generally found at the corners.

Grinding cracks are prone to occur in special alloy steels as a result of their low thermal conductivity. Overhead steels are more likely to show grinding cracks since they have greater strains and more brittleness. Tempered tools are less sensitive than as quenched.

Sometimes cracks can be seen with the naked eye on a finely ground surface after it has been held for 2-4 hrs. in dilute hydrochloric acid at room temperature (the steel should first be annealed, as otherwise stresses inherent in a very hard tool steel may cause pickle-cracking which could then be confused with grinding cracks).

Cracks can also be observed after (1) etching in 1-2% nital; (2) electromagnetic testing such as Magnaflux; and (3) boiling in oil (oil is then wiped off and entrapped oil seeps out of cracks). (A. J. Schroeder in *Machinery (London)*, Vol. 59, Jan. 8, 1942, pp. 126-128.)

3 Design and Applications

METALS, ALLOYS, METAL FORMS ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep) • Corrosion and Wear • Engineering Design of Metal-incorporating Products • Selection of Metals and of Metal-Forms • Competition of Metals with Non-Metals • Specific Applications of Metals and Alloys

CONTENTS

Plastics as Engineering Materials

Condensed from *N. E. Coast Instn. Engrs. & Shipbuilders*

Among the large organic molecules naturally occurring are rubber, gutta percha, natural resins, cellulose, lignin and the proteins, not all of which are mouldable. It is noteworthy that, although many of the synthetic plastics have been known to chemists for some time, the industrial development of nearly all of them has taken place largely in the last 10 yrs.

In order to gain any appreciation of the engineering possibilities of plastics, it is necessary to know something about the structure of their large organic molecules and the aggregate of molecules, such as is obtained from X-ray measurements. The two limiting crystal types for plastics are considered as paraffin wax with a linear structure, and the diamond with a block structure.

The phenol-formaldehyde plastics are three dimensional structures, very imperfect compared with the diamond structure, but in combination with linear molecules of cellulose fibers become usable engineering materials. Weathering and aging properties, resistance to alkalies, acid, exposure to sunlight etc., are all factors in evaluating utility. It is disappointing to be told that a plastic has a specific strength and Young's modulus equal to that of steel at 70° F., and then to find that these properties are halved at 100° F.

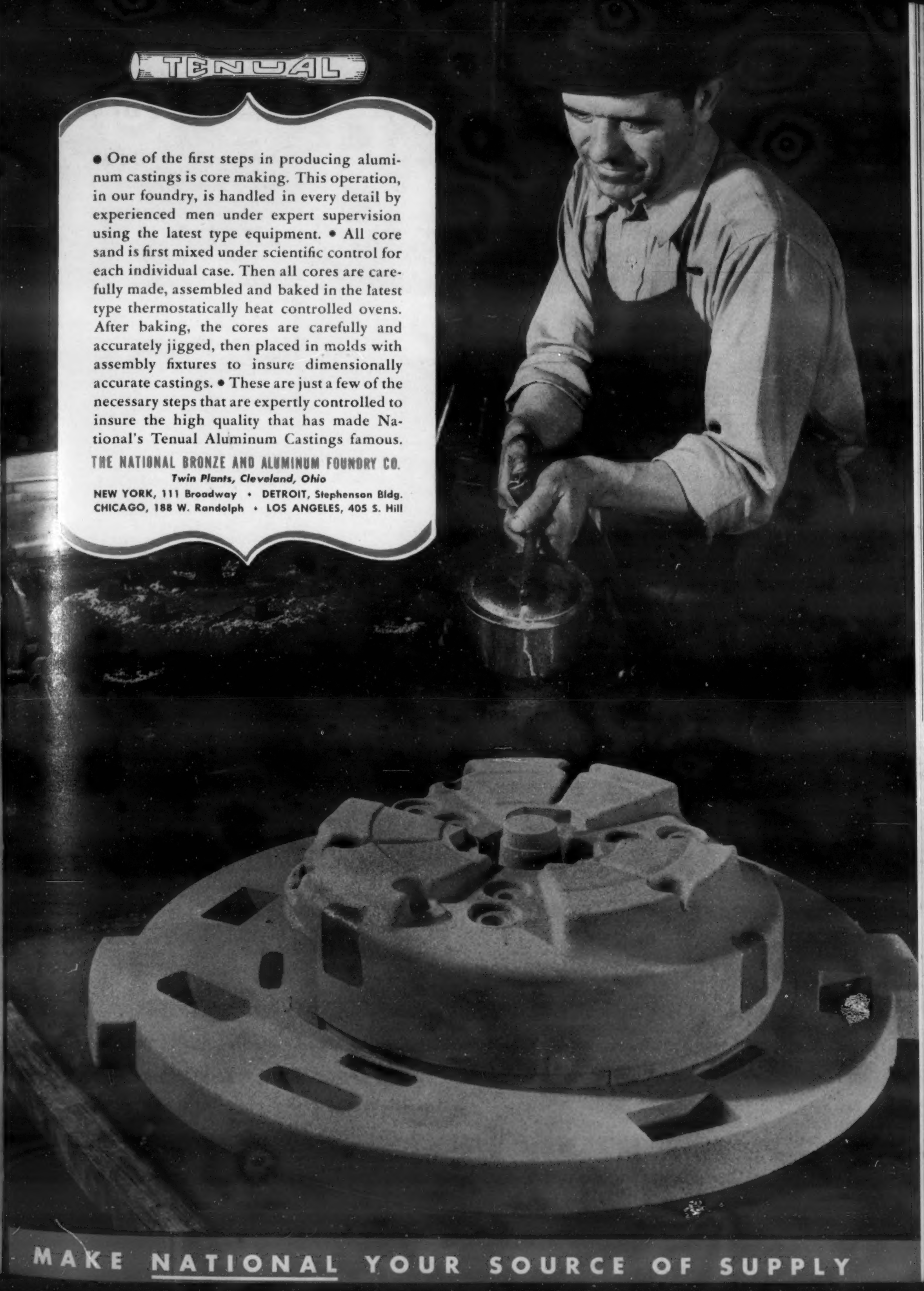
The linear and two-dimensional plastics are thermoplastic, but the three dimensional plastics are thermosetting. The latter however, are deformed by stress at sufficiently high temperatures. It is, therefore, necessary to determine stress-strain cycles over a range of temperatures for stresses ranging in magnitude and nature.

Engineering Properties

The range of properties is given as (1) *Density.* Densities range from about 0.95 (polythene) to 1.7 (polyvinylidene chloride). Much lower densities are obtained, of course, by foaming the resins and higher densities by the use of heavy mineral fillers (cf. glass about 2.5, aluminum 2.7, steel 7.8).

(2) *Tensile strength.* The range is from 2,000 lbs./in.^{2} for polythene, 4,000 upwards for cellulose derivatives, 6,000 for polystyrene, 9,000 for polymethylmethacrylate to 20,000 for rolled nylon sheet. The tensile strength of the three-dimensional plastics depends on the filler—*e.g.,* unfilled phenol-formaldehyde, 6,000-9,000 lbs./in.^{2} cellulose filled phenol-formaldehyde and urea-formaldehyde moldings 8,000-9,000; phenol formaldehyde laminated, up to 30,000; and special fibre-reinforced phenol-formaldehyde, up to 60,000 (compare with duralumin at 60,000, and certain heat treated steels at about 200,000 lbs./in.^{2}).

The effect of cold-drawing is most marked. Polythene increases to 5,000-14,000 lbs./in.^{2}, "Saran" (an interpolymer with vinylidene chloride preponderating) is claimed to have a tensile strength up to 60,000 lbs./in^2., and nylon increases to 50,000-120,000 depending on the method and extent of drawing.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• One of the first steps in producing aluminum castings is core making. This operation, in our foundry, is handled in every detail by experienced men under expert supervision using the latest type equipment. • All core sand is first mixed under scientific control for each individual case. Then all cores are carefully made, assembled and baked in the latest type thermostatically heat controlled ovens. After baking, the cores are carefully and accurately jigged, then placed in molds with assembly fixtures to insure dimensionally accurate castings. • These are just a few of the necessary steps that are expertly controlled to insure the high quality that has made National's Tenual Aluminum Castings famous.
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(3) *Ultimate Fibre Strength in Bend.* The trend of tensile strength is naturally followed by the bend strength, which, however, is higher in plastics, *e.g.*, 5,000 lbs./in.^{2} upwards for cellulose derivatives; 7,000 for polystyrene; 14,000 for polymethylmethacrylate; 16,000 for "Saran"; 10,000-12,000 for cellulose-filled phenol-formaldehyde and urea-formaldehyde moldings, with laminates correspondingly higher.

(4) *Compressive Strength.* The range for linear polymers is 10,000-15,000 lbs./in.^{2} Phenol-formaldehyde and urea-formaldehyde plastics are higher, *e.g.* moldings and fibre-reinforced products have compressive strengths up to 35,000 lbs./in.^{2}, approaching that of duralumin.

(5) *Young's Modulus.* Unfilled plastics do not approach metals in elastic modulus. The normal range for the thermoplastics is 2×10^5 to 5×10^5 lbs./in.^{2} with some cellulose derivatives down to 1×10^5. The thermosetting plastics, as would be expected from their cross-linked structure, have higher moduli, 7×10^5 to 10^6 for unfilled phenol-formaldehyde, going up to 7×10^6 for fibre-reinforced phenol-formaldehyde. Compare these with duralumin (10^7) and steel (3×10^7) lbs./in.^{2}

(6) *Impact Strength.* Plastics are generally brittle compared with metals, and again the thermosetting plastics do not compare favorably with the thermoplastics, unless they are fibre-reinforced. Published figures are not always reliable because the exact method of test is not always stated. The probable order, in increasing impact strength, is: unfilled phenol-formaldehyde and cellulose-filled phenol-formaldehyde and urea-formaldehyde moldings, polystyrene, polymethylmethacrylate, cellulose derivatives (which, however, become brittle below 30° F.) polythene, fibre-reinforced phenol-formaldehyde, cold-drawn nylon.

(7) *Hardness.* With a 2.5-mm. diameter ball and a 25-kg. load, Brinell hardness figures range from 20 to 50 for phenol-formaldehyde, with nylon considerably harder. Cellulose derivatives and polythene are below 20. The abrasion resistance of typical transparent plastics is indicated by the following relative figures: polystyrene 12, "Perspex" (plasticized polymethylmethacrylate) 18, cellulose nitrate and acetate 22, polymethylmethacrylate 30, glass 130.

High-Temperature Properties

(8) *Thermal Properties.* Conductivities range from 10^{-4} to 10^{-3} c.g.s. units. Specific heats are between 0.25 and 0.5 per °C. Linear expansion coefficients per °C. are between 1.6×10^{-5} and 1.6×10^{-4}—generally higher than metals, cellulose derivatives being the highest.

(9) *Useful Temperature Range.* Most plastics can be used at temperatures down to at least —40° F. The linear thermoplastics weaken with rising temperature and the upper limit for continuous service is around 140° F., for some plasticized compositions even lower. Nylon with a sharp melting point of 507° F. can be used up to temperatures approaching 400° F., but attack by oxygen becomes a limitation at high temperatures.

The thermosetting plastics are naturally less affected by temperature, but cellulose-filled phenol-formaldehyde moldings are serviceable at 280° F., and with heat resisting fillers up to 350° F., or higher. The words "softening point" is used unfortunately with a number of different meanings, and unless defined more exactly, it cannot be taken as any indication of the upper limit of temperature at which a plastic can be used.

The present uses of the various plastics are cited and the prediction is made that if perfectly ordered cross-linking of the plastic molecules were possible, as in the diamond, it might be possible to produce a constructional material with properties approaching those of metals. (A. Caress in an *Advance Paper, N. E. Coast Instn. Engrs. & Shipbuilders,* Dec. 1941 meeting, 19 pp.)

Corrosion by Superheated Steam

Condensed from *J. Am. Soc. Naval Engrs.*

An investigation has been underway at Purdue University since 1934 on the effect of steam pressure, types of surface shapes and finishes, time of exposure to high temperature steams, effect of temperatures between 1000° and 1300° F., and the influence of temperature fluctuation on the corrosion resistance and spalling of alloy steel samples.

Corrosion tests were made by sandblast-

Advertisement MAY, 1942

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

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Memos on Brass—No. 28

Because it is probably the most economical way of making strong, precise, intricate articles at high speed with little waste, the cold heading process is playing an important part in the nation's war production of bolts, compression nuts, screws, and many other similar parts. Although it is an unusually severe operation, brass is admirably adapted to cold heading because it is malleable before cold working and acquires high strength without becoming brittle. However, each heading job requires the right alloy, correct stiffness, proper grain structure, uniformity, and freedom from minute imperfections. Close cooperation between the laboratory and the mill has enabled Bridgeport to supply brass wire with marked advantages.

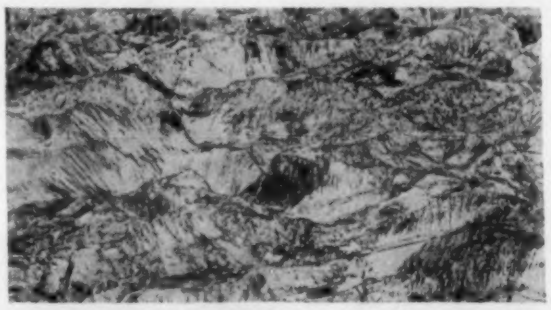
Typical of Bridgeport's constant efforts to find clues to higher quality brass mill products is the operation of the modern tensile testing machine shown above. Capable of exerting many thousands of pounds of tension, this machine is used in testing Phono-Electric* Wire, brass pipe and tube, Duronze* and similar rods which are made to definite physical specifications.

Directional Properties Important In Bending Cold Worked Material

Cracks or Fractures in Copper Alloys Can Be Avoided By Making Sharp Bends in the Direction of Rolling

Springiness, stiffness and strength of copper alloys are controlled largely by the amount of cold working or per cent reduction by rolling or drawing which the material receives after the last annealing treatment at the mill. Cold worked material, however, possesses directional properties which must be taken into account when articles such as electrical spring contacts, spring washers, brackets and other angle sections which require sharp bending are made from it.

Spring temper sheet shows much more decided directional properties than metal rolled half hard (2 B & S numbers), as is clearly indicated by the fact that bends made across



Rolled metal magnified 75 X. Note that crystals have been elongated in the direction of rolling.

the grain (90 degrees to the direction of rolling) are less apt to crack than bends made parallel to the direction of rolling.

Temper Affects Bending

Alloys that are inherently ductile are less apt to crack when bent sharply than those which are less ductile, which explains why Phosphor Bronze and Silicon Bronze have a greater tendency to fracture than yellow brass of equal gauge and temper. The temper or degree of hardness of the material, as determined by the amount of cold rolling after the last anneal, has a great deal of effect on the ability of the material to take certain bends.

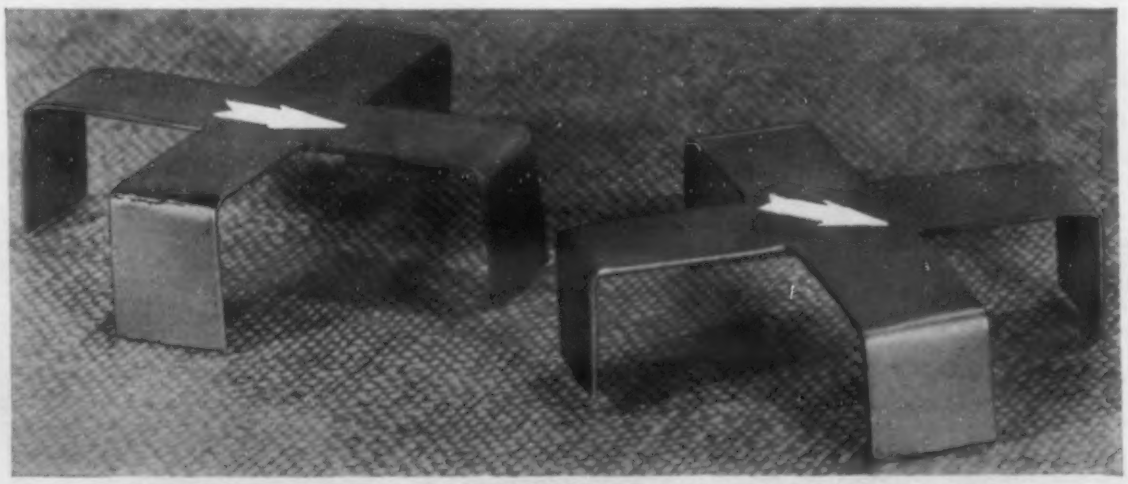
In general, material which has been rolled one or two numbers B & S hard, 20 per cent reduction in cross-sectional area, will take any reasonable bend. However, for severe sharp radius bends, in particular where further cold working is necessary, the use of soft metal is recommended. On cold working reductions over number 2 B & S hard, the effect of thickness or gauge, radii of the bends, and the direction of the bend in respect to the direction of the cold rolling of the material, as supplied by the mill, are definite factors.

Thickness Important

It has been found as the thickness of the material increases that there is more danger of fracture for any certain bend without changing the temper or radius of that bend. This may be explained by the fact that, because of the heavier metal, the outside section has to stand a greater elongation as it has a greater distance to move in order to reach the required degree of bend.

The radius of a bend is a decided factor in determining whether a given degree of bend will fracture. In this connection it could be said that *the smaller or sharper the radius for any given temper, the more likelihood there is that fracture may occur*. It is important, therefore, that the design of the part to be made should be such as to allow as liberal a radius as possible.

(Continued on page 2, column 2)



Phosphor Bronze samples bent parallel (left) and at 45 degrees (right) to the grain. Note the absence of cracks in the latter. White arrows indicate the direction of rolling.

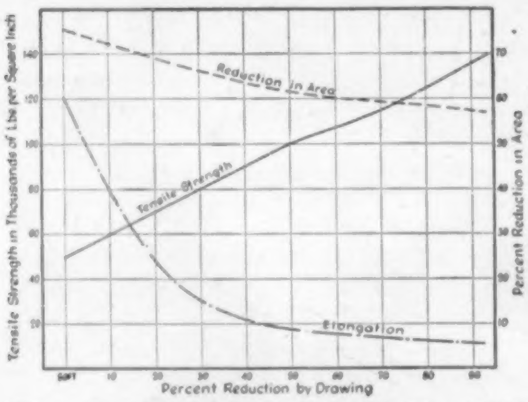
ALLOYS OF COPPER

This is the thirty-third of a series of articles on the properties and uses of the copper alloys.

COPPER-ALUMINUM SILICON ALLOYS

As was mentioned in this column last month, copper-aluminum alloys are often modified by the addition of silicon to increase their strength and hardness.

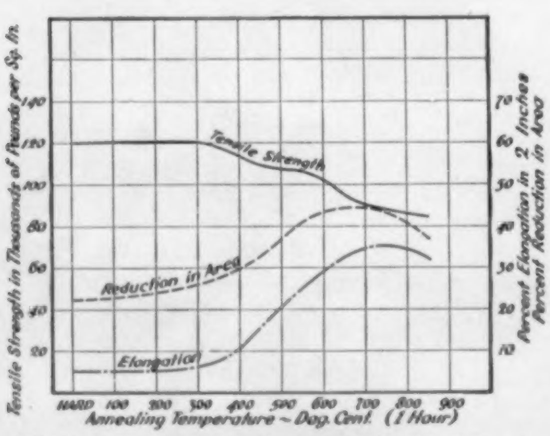
One such alloy that is used commercially contains approximately 96½% copper, 3% aluminum and ½% silicon. It is a ductile alloy with a moderate tensile strength in the annealed condition, but one which develops a very high tensile strength when reduced severely by cold drawing. This alloy is used as catenary wire and cable for electrified railroads where high strength, low creep and good corrosion resistance are more important than high electrical conductivity.



Effect of cold drawing on alloy containing 96½% copper, 3% aluminum and ½% silicon.

Another modified copper-aluminum alloy that is used commercially contains approximately 91% copper, 7% aluminum and 2% silicon. It is essentially a hot working alloy which is characterized by great strength and hardness but comparatively low cold workability. It can be forged readily and is supplied in rod form only. Although it does not

(*Continued in column 2*)



Effect of annealing on alloy containing 91% copper, 7% aluminum and 2% silicon.

Bending Suggestions

(*Continued from page 1, column 3*)

Direction of Rolling

Another very important factor is the *direction* of the bend in relation to the direction the material was rolled. As mentioned earlier in this article, there is more danger of cracking when the bend is parallel to the direction of rolling than across the grain. It has been found, however, that some position, such as 45 degrees to the direction of cold rolling, may give the best results on hard rolled metal, which must be springy and at the same time must take sharp bends.

It is important that the tool designer should give careful consideration to all of these factors in laying out a set of tools in order to get maximum spring properties, the greatest ease in bending without fracture, and economy in the width and gauge of the material desired. Bridgeport's laboratory service is available to help customers with their metal problems.

300 Pieces of Copper Form Miss Liberty

The Statue of Liberty, a symbol of freedom that stands out as a shining ray of hope to the world today, was constructed of 300 separate pieces of 3/32-inch thick sheet copper. When the pieces arrived in this country in 1885, they were fitted together like a huge jig-saw puzzle and riveted. The 152-foot high figure is said to weigh about 25 tons. Its green color is caused by patina, a protective coating formed on copper which preserves the metal against time and the elements.

ALLOYS OF COPPER

(*Continued from column 1*)

contain lead, this alloy machines freely. Annealed rod averages about 90,000 lbs. per square inch in tensile strength, while commercial drawn rod is nearer 100,000 lbs. When annealing hard drawn rod, softening begins at about 350° C. Its maximum ductility is reached between 700 and 750° C., when the tensile strength drops to about 85,000 lbs. per square inch—a remarkably high figure for an annealed material. Stated differently, the high strength of this alloy is inherent rather than artificially produced by cold working.

Commercially known as Duronze III, this patented alloy is made by Bridgeport. It is used for the manufacture of high strength screw machine products and hot forgings where greater strength than that of brass or ordinary silicon bronze is required.

NEW DEVELOPMENTS

A paste cutting compound has been put on the market for use on hand milling, threading, drilling, tapping and automatic machines. It is said to leave no grease, be clean to use, and to leave a protective film that prevents rust. The compound is mixed with water to form a thick solution which the maker claims will flow readily and not separate or congeal. **(No. 320)**

A semi-automatic cut-off saw has been designed for accurate high speed cutting of tubes, rods or shapes up to 3" O.D. It is said to handle either steel or non-ferrous metals. The saw is equipped with an air-operated cam action chuck which is claimed to hold material with sufficient pressure to avoid slippage or rotation while the saw is passing through. **(No. 321)**

Dual ram broaching machines have been designed for fast production ranging from three tons and 36" stroke up to 25 tons and 66" stroke. The maker says an operator can handle feeding and removing a part from one ram while the other is on its down stroke, thus doubling the output per man. **(No. 322)**

A double end boring bar has been designed for use with saddle type turret lathes. It fits into the standard flanged tool holder on the turret, then through the turret, and is held on the opposite side by a short holder having four screws to firmly grip the bar. It is described as making an extremely rigid bar with large single point cutters for use with a cross feeding turret. **(No. 323)**

A brake for bench use has been put on the market which is said to accurately form non-stock size angles, channels, and Vees in sizes ranging from 1.8" dimension width of each member and upwards to 110 degrees of radii without change of the original contact surfaces. It is designed to handle work in the range between that done on heavy floor type brakes and a bench vise or pliers. **(No. 324)**

A three point pitch diameter gage which uses ball locating points and is said to equal the results obtained by the 3-wire method of checking threads has been introduced. Two lower ball locating points can be adjusted laterally, so as to check different thread sizes. Different sets of points are used for various thread pitches. Pitch diameters up to 2" can be accommodated and inspection within 0.0002" is said to be possible. **(No. 325)**

An adjustable hand tool holder has been developed to hold square or octagon shaped tools such as steel hand stamps and chisels in sizes from ¼" to ¾". Other sizes, each with ½" range, up to 1¼". **(No. 326)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

ing steel samples to ensure uniform surface finish, weighing, subjecting to steam in a reaction chamber and removing scale anodically in an acid solution containing an inhibitor. For low-carbon steel tubes, the weight-loss method gives an equation: $W = 5.56\ (10^{-7})e^{0.0111t}$ for temperatures between 800° and 1100° F. (t is surface temperature and W = weight loss).

A test of the effect of pressure on corrosion of low-carbon steel tubes at 1100° F. indicated absence of any pressure effect for pressures between 400 and 1200 lbs./in.[2] gage, therefore experimental conditions could be simplified to vary the temperature while pressures were maintained at low level.

For alloy steels the corrosion rate decreased as chromium content increased. Except for the high-chromium steels, corrosion increases rapidly above 1100° F.; above 7% Cr the protective effect is pronounced, while 12% Cr and 18-8 stainless steels are particularly resistant even at 1350°-1400° F. steam temperatures.

Parallel tests with some carbon, carbon-moly and other alloy steels indicated a similar trend. Fluctuation in temperature was found to be a minor factor in causing spalling and cracking of scale. (H. L. Solberg, G. A. Hawkins & A. A. Potter in *J. Am. Soc. Naval Engrs.*, Vol. 53, Nov. 1941, pp. 705-723.)

Underground Pipe Protection

Condensed from *J. Research, Nat'l. Bur. Standards*

The protection afforded by zinc coating in soils depended on the thickness of the coating and was not appreciably affected by the kind of ferrous material to which the coating was applied. The superior protection which was provided by a 3-ounce zinc coating specially applied, as compared with a commercial coating of the same weight, may indicate that uniformity of coating is important.

Lead coatings applied to iron and steel have not proved adequate for protection underground. Since the potential of lead is cathodic to that of iron, lead cannot protect iron or steel cathodically in the manner that these metals are protected by a zinc coating. As the rate of corrosion of lead is appreciable under many soil conditions, a continuous layer of lead isolating steel from the environment cannot usually be maintained.

Tin-coated copper is susceptible to corrosion in soils which are corrosive to copper. In fact, in some soils the rate of pitting of copper appeared to be accelerated. Under certain conditions one or more tin-copper alloy layers may be cathodic to copper, a condition which would accelerate corrosion.

After exposure to soils for 15 yrs. two hot-dipped asphalt and coal-tar coatings were found to have failed, as indicated both by pitting of the underlying metal and deterioration of the coating. Of the group of experimental coatings exposed 7 yrs. a vitreous-enamel coating and two hard-rubber coatings afforded complete protection.

In the group of coatings exposed 2 yrs. a Bakelite coating consisting of several coats of Bakelite varnish, each coat being baked on, afforded the most satisfactory protection. The air-dried Bakelite coatings blistered somewhat and permitted some rusting, but severe corrosion under these coatings occurred only in cinders. (Kirk H. Logan in *J. Research, Nat'l. Bur. Standards*, Vol. 28, Jan. 1942, pp. 57-71; continuation of the so-called "Soil-Corrosion Studied"—see METALS AND ALLOYS, Vol. 11, Jan. 1940, p. ma 36.)

How Spot Welds Resist Impact

Condensed from *Welding Journal*

Designers need information on fatigue and impact properties of spot welded structures in addition to the available static properties. The specimen used in these tests consisted of two ¾-in. wide strips lapped 1 in. and welded with a single spot, which is tested in shear impact. Thickness of all material tested was 0.050 in., and the metals studied were mild steel, low-alloy steel (Cor-Ten), 18-8 stainless (annealed, cold rolled).

Shear strengths (static and impact) were determined for different timing of the welds, 4, 7, 10, 15 and 20 cycles of current. The results are plotted showing

600

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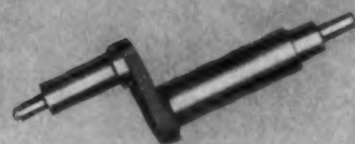

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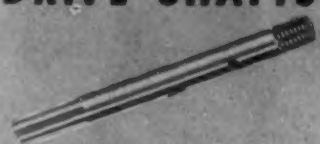

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600 Metal is a true bearing metal and—an entirely different one. It has a structure made up of two types of crystals—soft and hard. In this alloy, the hard crystals are elastically and very uniformly embedded in a matrix of soft crystals. The hard crystals absorb the pressure in the bearing, diminish the friction, and cause a better distribution of lubricating oil between bearing surfaces.

600 is a superior material for high speeds at light loads or for slower speeds at heavy loads running against hardened, well finished shafts. Because of its own hardness, it is not suited for running against soft steel at heavy loads.

600 has been successfully used for the past 14 years in many thousands of auto and truck transmissions, for pump rods, propeller shafts and power boats; in worm wheels, small and large, in cams and cam rollers, and for thrust collars, seal rings and a thousand other uses.

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shear strength (pounds per spot) vs. amperes and versus spot diameter; impact strength and impact elongation are plotted versus spot diameter for the various current timings.

For mild steel, welds made with the shortest timing gave the greatest impact strength, due to the most rapid quench, producing weld metal with maximum hardness and strength. The surrounding base metal yields at higher stresses and absorbs greater energy.

For the mild alloy steel (Cor-Ten) there is not as much difference between the long- and short-time welds as with mild steel, and for the larger welds the difference is negligible.

For the annealed 18-8 stainless the trend is the same as with mild steel, but the difference is not so great, since there is not much change in hardness between base and weld metal. For cold rolled 18-8, the impact strength decreases from 4 to 10 cycles, and then increases from 10 to 20 cycles, but the differences are slight. (A. M. Unger, H. A. Matis & E. P. Gruca in *Welding J.*, Vol. 21, Feb. 1942, pp. 94s-98s.)

New Wartime Uses for Silver

Condensed from *Steel*

The industrial consumption of silver alloys has increased from a few thousand ounces a decade ago to several million ounces in 1941. An important use of alloys containing 2½-80% Ag is for brazing and soldering virtually all non-ferrous metals and iron and steel.

Recent applications of silver brazing include joints in brass ignition-wire shields for aircraft engines, preventing radio interference; pipes and tubes in ships for liquids, gases and gun-fire control systems; and aerial bombs, gun recoil cylinders, machine-gun water-jackets, chemical shell, torpedo pressure lines and discharge tubes, and field kitchen stoves.

For electrical contacts and brushes, alloys and sintered mixtures of silver and nickel, copper, cadmium, molybdenum, tungsten, palladium and carbon provide a product particularly resistant to wear, arcing, sticking and corrosion. Clad or inlaid silver is also used. When not subjected to wear, contact surfaces may be silver-plated to minimize corrosion and maintain low contact resistance.

Coil silver containing 10% Cu and sterling silver make good contacts. Carbon brushes containing silver have both low contact and low internal resistance.

Split-shell and complete-ring aircraft-engine bearings can carry higher specific loads when an electrolytic coating of silver is first applied. Some complete rings for master rods of radial engines are coated both inside and out. Heavy coatings are first deposited, then machined to precision limits. Factors involved are higher softening temperature, corrosion resistance to lubricants, and high thermal conductivity.

Silver is replacing aluminum as reflective coating for "sealed-beam" headlights. It is applied by condensation and protected from the sulphur in the atmosphere by a glass bulb which is evacuated. Solid silver or silver-clad sheet is widely used in chemical plants in evaporators, heating coils, heat exchangers, drying pans, retention vessels, and similar equipment.

By silver-brazing high-tungsten-alloy tips to cutting-tools, tungsten is saved since the shank can be of low-carbon steel. Tin can be conserved by substituting silver in high-tin Babbitt and in soft solders where 2½-5% Ag with remainder lead makes a solder that can replace the common 50-50 lead-tin variety. (Herbert Chase in *Steel*, Vol. 110, Mar. 2, 1942, pp. 86-112.)

Cobalt—Its Uses and Substitutes

Condensed from a report of the Advisory Committee on Metals and Minerals, National Research Council, National Academy of Sciences

The United States depends chiefly on the Belgian Congo for its supplies of cobalt. In the unfortunate event that supplies from the Belgian Congo should be shut off, the United States would face the problem of finding substitutes or developing

low-grade deposits, some of which probably could be placed in production as an emergency supply.

Use in Cutting Tools

An important use for cobalt is in the manufacture of high-speed cutting tools for operation at high speeds or at high temperatures. It also is employed in alloy steels for high-temperature dies, heavy-duty shears, and other implements requiring extreme toughness combined with great hardness at high temperatures. Certain high-temperature, non-corrosive alloys are made with small amounts of cobalt in their composition.

The so-called cobalt high-speed steels are, in general, simply modifications of the familiar "tungsten steels" and the "molybdenum steels." The addition of cobalt to standard high-speed steels improves their cutting performance under some conditions. It is not substituted for any other alloying metals.

Tungsten steels are improved by the addition of cobalt in amounts up to 12-13%. In general, the cutting ability is proportional to the cobalt content up to about 13%.

The improvement in properties by the addition of cobalt is equally apparent in the case of the molybdenum high-speed steels. Cobalt is added to such steels in amounts up to 13%.

Cobalt steels are utilized in cutting cast iron, hardened steels, and, in general, in making heavy or hogging cuts. Their cutting efficiency is not so high on softer materials. High-cobalt steels are inclined to be brittle, which is counteracted to some extent by the vanadium content.

Cobalt is also a necessary constituent of other cutting alloys, such as those of the stellite types and cemented carbides. The chromium-cobalt-tungsten alloys and the carbide materials represent perhaps the most efficient heavy-duty high speed, high-temperature, cutting and die materials available. The rapid expansion in cemented carbide use will call for a corresponding increase in cobalt.

Substitutes for Cobalt in Tools

There is a considerable tendency to regard the use of cobalt in high-speed steel as absolutely indispensable. According to some experts, there is no known substitute for cobalt in high-speed alloys for the particular applications to which they are subject. On the other hand, others are of the opinion that the use of cobalt in high-speed steel could be substantially reduced if necessary.

Gill suggests the following compositions as substitutes for many applications of cobalt high-speed steels:

	1	2	3
Carbon	1.00	1.25	1.2
Tungsten	18.00	...	5.5
Molybdenum	....	8.00	4.5
Chromium	4.00	4.00	4.0
Vanadium	3.00	4.00	4.0

In some cases these steels give better performance than the cobalt steels.

Many of the applications of cobalt steels are for single-point cutting tools, and cemented carbide tools can often be substituted to advantage, or the cobalt steel can itself be used as insert cutting tips instead of solid tools.

Tantalum has been patented as a substitute material for cobalt in high-speed steels of all kinds. The examples given are steels containing 0.75% C, 4.5 Cr, 18 W, 0.5 V and 8 Ta; also steels containing 0.5% B and 0.5-50 Ta (*Sic*).

Use in Permanent Magnets

Permanent magnets are employed in electric meters, relays, regulating devices, fractional horsepower motors and generators, switching appliances, and a variety of other uses too numerous to list. Most high-performance permanent magnets contain cobalt.

For the present purpose, permanent magnet materials have been classified under 3 headings: (1) Magnet steels, which are iron-carbon alloys containing various other elements and which can be cast, annealed, forged, machined, or otherwise shaped by mechanical work and subsequently hardened into a martensitic steel and magnetized; (2) precipitation-hardening alloys containing essentially no carbon, which must be rendered magnetic by aging at elevated temperatures; and (3) oxide magnets, which are made from metal oxide powders pressed into desired shapes under great pressures and subsequently sintered.

Commercial cobalt steels range from a

few per cent cobalt up to 40% Co, and generally carry about 0.9% C. The performance product (B_rH_c) is directly proportional to the cobalt content.

The precipitation-hardening magnet alloys differ from the magnet steels in that the metals contain little or no carbon, are not magnetic as cast, and are given the desired properties by precipitation of one or more of the alloying constituents from a solid solution under controlled conditions. They represent the highest-performance magnetic alloys known.

Their mechanical properties are, in many instances, detrimental for certain applications because some of the alloys are brittle and cannot be forged or machined. These brittle alloys are used where magnet designs permit casting of the final magnet shapes. These magnet materials can also be prepared through powder metallurgy; small pieces, and those of intricate shape, can be satisfactorily fabricated in this way.

In 1931, Mishima patented a number of iron-nickel-aluminum alloys, which were shown to have extremely high coercive force after proper heat treatment and magnetization. Development of modifications of these alloys and other alloys that could be hardened by precipitation proceeded rapidly, and now there are numerous alloys known to have superb magnetic properties for permanent magnets.

Substitutes in Magnetic Materials

From the voluminous data given in the report, the following conclusions can be drawn with regard to substitutes for and conservation of cobalt in permanent magnets.

(1) Molybdenum (dispersion-hardened) and tungsten-chromium-molybdenum (dispersion-hardened) alloys containing no cobalt can be substituted with little or no change in magnet design for the ordinary commercial low-cobalt magnet steel.

(2) Nickel-aluminum alloys with no cobalt can also replace commercial low-cobalt steels where the magnet design permits casting the finished shape.

(3) Molybdenum (dispersion-hardened) and tungsten-chromium-molybdenum (dispersion-hardened) alloys containing no cobalt can replace the chromium-cobalt commercial magnet steels with little or no changes in magnet designs.

(4) Nickel-aluminum alloys with no cobalt or with small amounts (up to 5% Co) might also be substituted for the chromium-cobalt commercial alloys containing 16% Co in applications where no forging or machining is required.

(5) Precipitation - hardened alloys containing 6-10% Co and 16-19 Mo probably can be used in place of the tungsten-cobalt commercial steels containing 17% Co. In this case, 16% Mo takes the place of 11% Co.

(6) Various iron - nickel - aluminum alloys with no cobalt of the Mishima type might replace the tungsten-cobalt steel of commerce.

(7) There are few, if any, possibilities of a substitute for 35-41% Co steels where machined magnets are essential. One solution might be to redesign the magnets to permit utilization of metals with lower cobalt content or one of the substitutes therefor.

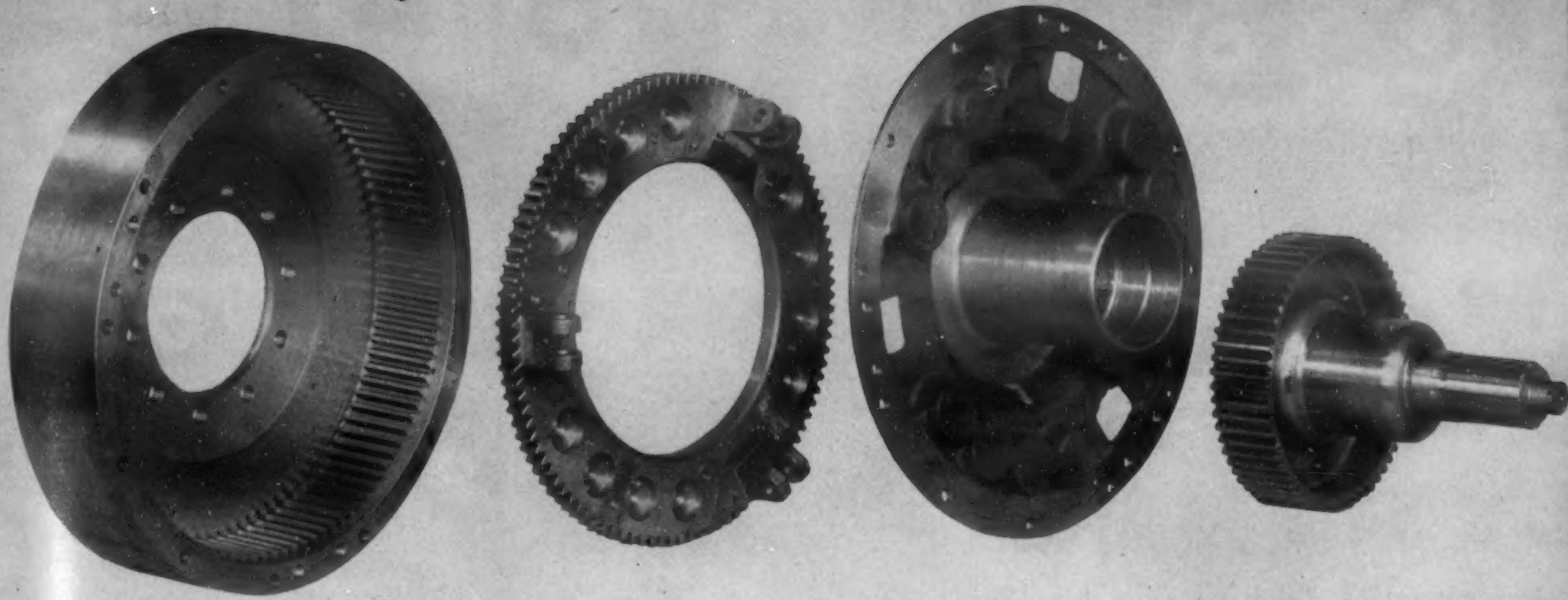
(8) A number of possible substitutes for 35-41% Co steels can be found in the Mishima-type alloys and are applicable where no mechanical forming is needed.

(9) There is no known substitute for cobalt in the extremely high performance alloys of the Alnico and the "new KS" types.

From the strategic standpoint, the use of aluminum, nickel, tungsten and chromium as substitutes for cobalt in magnets does not seem to be very logical, but the quantity of these metals that would go into magnets would be relatively small compared to the tonnages used elsewhere. On the other hand, the quantity of cobalt saved would be relatively large.

Molybdenum presents no strategic problem for this country, and most attention should be devoted to that metal as a substitute for cobalt in metallurgical application. (John Koster & H. W. Davis of U. S. Bureau of Mines in a report of National Academy of Sciences to the WPB, Jan. 7, 1942, 26 mimeographed pp.)

Driving Power FOR TANKS



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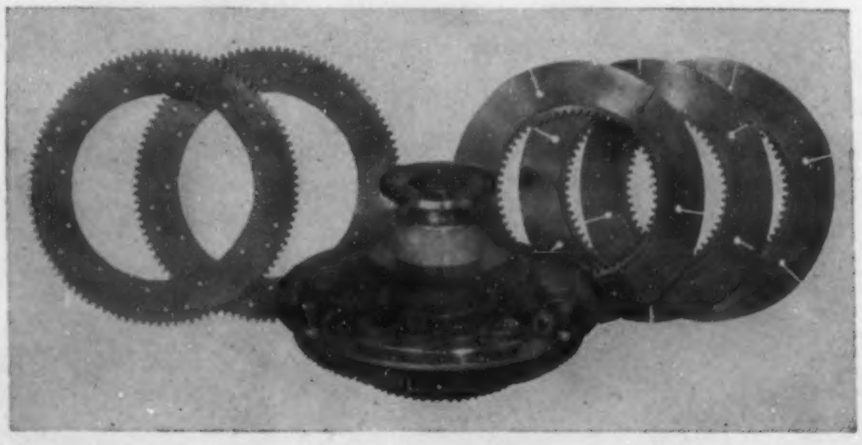

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Testing and Control 4

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection • Routine Control and Instrumentation • X-ray and Magnetic Inspection • Spectrographic and Photoelastic Analysis • Corrosion- and Wear-Testing • Examination of Coatings, Surface Measurements • Metallographic Structure and Constitution

CONTENTS

Weldability Testing

Condensed from *Welding Journal*

Further weld-quench studies on a series of low alloy, high strength steels are reported. It was found that heat treatment of a half-size Charpy bar could reproduce the heat-affected zone next to a weld.

The thermal cycle of the heat treatment and of the base metal next to the weld deposit were obtained and compared. The differences between the two curves are shown to be slight, and for similar steels the resulting microstructures from the two methods of heat treatment are comparable.

For wide differences in chemical composition, the weld quench specimens may not have a microstructure comparable with the zone next to the weld. Where reproduction of the heat-affected zone microstructure is attained, and the hardness values are within 90% of the maximum in this zone, the weld-quench impact value is considered a good index of weldability.

Three steels were selected for a survey of results of weldability tests, and the corresponding "S" curves of constant-temperature transformation. The latter were obtained for a 1600° F. quench and for a 2460° F. quench. A considerable shift and change of shape of the curves resulted from the 2460° F. quench, as compared with the "S" curves for the 1600° F. quench.

For a low-alloy steel containing low-carbon, the shift to the right with respect to the log of time is not sufficient to prevent the austenite from transforming at a high temperature to lamellar pearlite. For the high-carbon, low-alloy steels, the transformation takes place at lower temperatures, resulting in higher hardness and loss of impact values.

The single bead welding test is considered to have the most promise for weldability studies in that the effect of the actual heat treatment during welding can be determined by a variety of methods, such as hardness tests, micrographic surveys, bend tests and other physical and mechanical properties tests. (W. H. Bruckner in *Welding J.*, Vol. 21, Jan. 1942, pp. 55s-59s.)

Radiography of Aircraft Spot Welds

Condensed from *Welding Journal*

Coupon tests for aircraft materials have aided in the development of sound welds that consistently have the prescribed strength values, but a non-destructive test other than visual inspection for the assembled aircraft components has not been available. The background of radiographic technique is discussed, and it is shown that most of the difficulties encountered in radiography of thick sections do not exist in the inspection of thin sheet aluminum, such as is spot-welded for aircraft.

In the development of the radiographic, non-destructive test, all the company's test aluminum spot welds are routinely radiographed on Eastman Process film, and the resulting images studied under enlargement

up to 15 to 50 diameters. This fine-grain film requires longer exposure than X-ray film, but is more satisfactory than the latter for detecting fine cracks.

The process film is developed in X-ray developer for greater contrast than is attainable in the usual photographic solutions. The film is underdeveloped; 2½ min. rather than the 4½ min. required for X-ray film. Some of the defects—cracks, unfused areas, porosity, radial and peripheral cracking—are illustrated in the radiographs reproduced, and show the presence of the defective regions unmistakably.

The conclusions are that insufficient work has been done on the interpretation of spot weld radiographs to allow establishment of standards. At the moment, study of spot weld X-ray films will reveal the presence of cracks and permits their measurement; it will disclose various conditions of porosity, any pronounced chemical segregation, inclusion of foreign material and splatter as well as the detection of unfused areas.

"But to date," the authors say, "we are unable to point to any radiograph, and make an accurate guess as to what shear strength or fatigue resistance of the weld will be." The authors view the future of the research with considerable optimism. (R. C. Woods & S. L. Rich of Bell Aircraft Corp. in *Welding J.*, Vol. 21, Feb. 1942, pp. 101-104.)

Magnetic Inspection Procedure

Condensed from *The Iron Age*

The technique of Magnaflux inspection consists of magnetizing the part and then applying inspection medium. The inspection medium consists of finely divided ferro-magnetic material applied as a dry powder or as a suspension liquid such as oil distillate.

Either a.c. or d.c. current may be used for magnetization. The current flow may be as small as 0.00001 sec. in case of flash magnetization.

Results of tests described show that where an adequate amount of magnetizing current is used, the indication obtained with a current flow of 0.1 sec. would be considered satisfactory in most cases. The indication obtained with current flow of 0.5 sec. is satisfactory even when the magnetizing current is only 550 amps.

It appears that there is little to be gained by permitting current flow for a period longer than ½ sec. Indications obtained by a.c. were clearer than by d.c.

Flow lines from the standpoint of Magnaflux inspection may be considered as a surface indication, the excessive current bringing out the direction of grain flow. Study of sub-surface defects is difficult because these defects cause leakage fields (the basis of the Magnaflux method) that vary over wide limits. The factors causing these variations are the permeability of the steel and the shape, size and location of the defect.

The most satisfactory method of accumulating test data on sub-surface defects is to prepare specimens simulating such defects

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artificially. One method is to drill holes in pieces of the desired shape and size at varying depths. In general, the reluctance of such artificial gaps is greater than those caused by natural defects.

A.c. current is superior for surface defects while d.c. is superior for sub-surface defects. This is because a.c. has a distinct skin effect, and the higher its frequency, the less is the penetration of the magnetic field so generated.

Using the same procedure, the patterns obtained by the dry method are much more sensitive than those obtained by the wet method. Results show that the dry method is preferred for sub-surface defects.

Large powder particles should be used for maximum pattern build-up on large defects, and small ones for small defects.

With a concentration of ferromagnetic particles in the range of 1½ oz. of standard paste to 1 gal. of suspensoid, a period of 0.5 sec. of current flow is sufficient. There is some increase in pattern build-up when time is prolonged to 2 to 3 sec.

Patterns obtained with a.c. current are superior to those obtained with d.c. Sub-surface defects, with exception of those near the surface, are not well shown by a.c. as compared with d.c. Full wave rectified a.c. was slightly better than straight d.c.

Dry powder method is superior to wet method for sub-surface defects. (F. B. Doane & M. Mages of Magnaflux Corp. in *The Iron Age,* Vol. 149, Mar. 12, 1942, pp. 47-52; Mar. 19, 1942, pp. 56-58.)

Grids Aid Workability Studies

Condensed from *Light Metals*

It is well known in the tensile testing of metals, that the local deformation (necking) at the point of fracture is usually very high compared to the total deformation over a specified gage length. Or, putting the same idea differently, the per cent elongation becomes greater as the gage length decreases.

Local deformations in metal working, then, may be expected in certain cases to exceed by a considerable margin the measured per cent elongation of a tensile test specimen. Since this may be the case, the study of local deformations in deep drawing, for example, may be repaid by a clearer knowledge of what can be expected of a certain alloy subjected to a stated deformation.

Such studies can be readily carried out by the use of a superimposed grid on the specimen. Obviously, then, after deformation, one has only to measure a suitable number of elongated squares in a certain specified direction to obtain the desired information. Since most ductile metals are capable of higher local deformations than total deformations, studies of the grids could conceivably lead to press tool design so that consecutive stressing of small portions of the gage length could be accomplished.

A method of producing suitable grids photographically has been recently suggested (*J. Aeronautical Sci.* Vol 9, 1941, p. 1), called the photo-grid process. The surface of the test piece is coated with the usual photo-engravers dichromate-glue solution, and printed with a negative of the desired grid. After subjecting the photo-engraved metal to deformation, the area may be measured by some suitable means, or in some cases, enlarged photographs of suitable specimen areas may be more convenient for examination.

In deep-drawn 24S-O Alclad shells, compressive strains of 60% and tensile strains of 110% have been reported without intermediate annealing. Grids allow prediction of susceptibility to various forming operations, correlation of minimum permissible bend radii with maximum allowable local deformations, and prediction of spring-back.

For example, if the study of a grid showed that a drawn article suffers a maximum local extension of 30%, where it could stand 40% as shown by previous studies on similar shapes, the processing schedule could be changed accordingly to take advantage of the extra deformability.

In conclusion, it may be pointed out that deformation studies utilizing grids have shown that the average elongation measured by tensile test specimens gives a very incomplete picture of the deformation properties of a metal. The strain distribution curves determined by measurements of local deformations have, on the other hand, yielded very useful information, and the method will undoubtedly be used more in the future. (*Light Metals,* Vol. 5, Mar. 1942, pp. 54-58.)

Instrumentation in Heat Treating

Condensed from *Industrial Gas*

Industrial heat-treatment instrumentation should be designed individually and specifically for each job. This basic requirement is the result of several definite trends:

(1) The increasing complexity of the effect of heat treatment on the desired products.
(2) Marked advances in furnace and oven design with an increasing number of units being tailor-made to meet a specific job.
(3) Continuing advances in design, flexibility, etc., of instrument equipment to meet the demands of (1) and (2), above.
(4) Assistance that proper control can give in the overall cost of operation, increasing in its importance with improved furnace and burner designs and efficiencies.
(5) Increasing requirements for safety in operation.

Millivoltmeter pyrometers have in their favor simplicity, but in addition have the limitation of a relatively narrower scale, plus a limitation of types of control circuits to which they can be adapted. The potentiometer type of instrument, on the other hand, basically allows a wider scale, a suppressed scale if conditions demand, and flexibility of control adaptations.

A millivoltmeter properly compensated should be capable of an accuracy down to approximately 1% of the range of the instrument. The potentiometer, because of its system of operation, wider scale, etc., is easily accurate to within ¼-1/5 of 1% of the scale range.

The thermocouple is the prime mover of the entire control system and should be properly located. The heavier the thermocouple mass, the slower will the thermocouple be in picking up temperature changes. This may affect the limits of control within which the work itself is held, and thus becomes of particular importance in handling small-mass units.

Types of fuel-control mechanism available range all the way from the simple solenoid or stall-motor-operated valve to the proportioning type, with so-called automatic reset or load compensation. The simple two-position on-off or high-low control as afforded by the simple solenoid or stall-motor mechanism or two-position high-low motor valve should be used where the size and conditions of the job and the results expected do not demand more than this type can offer. This type of control can be applied to either a millivoltmeter or potentiometer type of instrument.

The so-called proportioning control, wherein the valve mechanism is moved proportionally to temperature demands, is coming into more and more use and should receive serious consideration on all but the simplest jobs as mentioned above. This type of control will handle the average batch or continuous furnace very satisfactorily, provided it is not called upon to meet too wide a range of conditions of loading, controlled-temperature range of the furnace, etc.

Where loading changes considerably or a furnace is to be run at widely different temperatures, the proportioning type of control can be used in conjunction with a hand-operated rheostat, or similar device, usually termed a manual-load compensator —or the proportioning control equipment can be equipped with so-called automatic-reset or automatic-load compensation.

In conjunction with the heat treatment of larger parts and alloy steels, particularly under the present war impetus, there is an increasing requirement for limiting the rate of heat input and exactly controlling the soaking time to insure even heat penetration of all parts of the work, involving in a number of instances light and heavy sections in the same piece. Under these conditions, so-called Program Control is available, whereby the furnace or charge can be brought up at a predetermined rate to the desired soaking temperature, and automatically held at this temperature for a predetermined time to insure thorough soaking. Then, if desired, a predetermined rate of cooling can be brought into effect, with a complete shutoff at the end of the program cycle.

One other system of temperature measurement, which is bound to have increasing application, is the radiation type of thermocouple operating through any standard instrument. As available now, these devices are sensitive and accurate to within a few degrees at work temperatures above 1000° F. and can be so located that they are affected only by heat radiation from the charge itself. In these instances the unit will be focused on the charge through an open-end tube installed in the furnace. (George P. Beck of Brown Instrument Co. in *Industrial Gas*, Vol. 20, May 1942, pp. 10-11, 18-21.)